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ERRATA.

Page 252, Title and elsewhere, for Santa, *read* Santo.
“ “ line 19, for Saybo, *read* Seybo.
“ “ line 6 from bottom, for Macorio, *read* Macoris.
“ 253, line 4, for cone, *read* core.
“ 254, line 5, for “ *read* “
“ “ line 2, for Pterocardia, *read* Pteroceroid.
“ “ line 19, for Citao, *read* Cibao.
“ “ line 5 from bottom, for but were much folded, *read* but ***nowhere*** were much folded.
“ 255, line 19, for north, *read* mouth.
“ 285, line 4 from bottom, for $\frac{86}{100}$, *read* $\frac{36}{100}$.
“ 294, line 14, for was, *read* were.
“ “ line 20, for outlines, *read* outliers.
“ “ lines 22 and 35, for Paraúquára, *read* Parauáquára.
“ “ line 27, after diorite, *insert* boulders.
“ “ line 28, for flanks of the serras, *read* flank of the serra
“ 295, line 22, for Para, *read* Pará.
“ “ line 27, for Almeyrine, *read* Almeyrine and Santarem.
“ “ line 28, after origin, *insert* deposited.
“ “ line 42, before they, *insert* as.
“ “ line 46, for —being, *read* bearing.

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THE

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[THIRD SERIES.]

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Art. I.—*On the Quaternary, or Post-tertiary, of the New Haven Region;* by James D. Dana.*

I. The Glacial era an era of Glaciers, and not of Icebergs.

It is still a mooted question in American Geology whether the events of the Glacial era were due to *glaciers* or *icebergs.* Agassiz and Guyot, who were long among the most active of Alpine explorers, found on their arrival in New England only the effects of glaciers. But American geologists are still divided in opinion, and some of the most eminent have pronounced in favor of icebergs.

The region of New Haven is exceedingly well situated for settling the question, not only as regards its immediate vicinity, but for the whole interior of New England. For in the first place, the region is a wide and open area at the southern termination of the Connecticut Valley;† and this valley is the great central valley of New England, including the larger part of its surface outside of Maine, the Green Mountains making its western border, and the White Mountains and the height of land southward, its eastern. Then secondly, the valley has a north-

---

* The principal facts relating to the New Haven Quaternary, which I propose to bring out in the article here begun, are included in a paper by the author on the Geology of the New Haven region, published recently by the Connecticut Academy, in volume II, of their Memoirs.

† The Connecticut Valley has a general course from north to south, varying little from S. 9° W. It is occupied by the Triassic (or Triassico-Jurassic) Red sandstone formation from New Haven to northern Massachusetts, and this indicates the position which it had in the Mesozoic era. The Connecticut river leaves the valley at Middletown, taking there a southeasterly course among the metamorphic rocks of the eastern half of Connecticut.

and-south course; so that, whether glaciers or icebergs were the agents, it would, in either case, have guided their great movements, and the New Haven region would have necessarily become filled with registers of the successive events. Being situated on an arm of the Sound, and at the same time extending inland for seven or eight miles along three streams that here have their discharge, the phenomena presented comprise results from both the sea and the rivers, and also from their combined action. On these several accounts, the New Haven region is eminently well situated for deciding the glacial question for all central New England.

A special study of the region during the last two years has led the writer to the conclusion that the effects are solely those of glaciers, or rather, of a *Connecticut valley*, or *Central New England*, *glacier.** To exhibit all the evidence bearing upon the question would require a full discussion of the whole range of facts presented by the New Haven Quaternary. I propose at this time to mention only a few of the more trenchant and decisive points.

The question is—Was the interior of New England in the Glacial era covered by a sea at least 4,000 feet deep for the floating of icebergs; or, was it emerged land as now, (perhaps to a higher level than at present) and submerged only beneath ice, the ice of an immense glacier, 3,000 feet and less in thickness, the ice in Vermont and New Hampshire being 4,000 feet and more above the level of the sea?

1. The sea, if it covered the land in the Glacial era, should have left proof of it along the southern coast of New England.

About New Haven, the height of the stratified Quaternary deposits above the sea (Long Island Sound), or above the river flats, no where exceeds 50 feet. This is the maximum; the particular facts will be stated at another time. Fifty feet is therefore the greatest amount of depression of the land which is indicated, the greatest that can be admitted by those who base their geological conclusions on facts. There are no traces of sea beaches or any thing corresponding thereto at a higher level. On passing the level of 50 feet above the Sound there is an abrupt transition from the stratified to the unstratified drift, except along the courses of streams, and near these, there is the same transition on passing the level of 50 feet (or less) above the existing river flats.

The highest sea-level of the Quaternary era about the New Haven region is thus definitely marked. It is often assumed that the *unstratified* drift might have been dropped over the hills by icebergs; but, as Mr. Croll has recently urged, depositions in water cannot be made without stratification. The slightest jar of a vat of water holding sediment suspended will cause that sediment to go down in a laminated state; and so deposits of sands and gravels in the ever moving sea will always manifest their aqueous origin. The stratified and unstratified material about New Haven therefore mark the limit between aqueous and dry-land deposition. Much has been said about "modified drift," or more or less stratified drift deposits, over the hills; but they occur no where, according to my observation, except along water courses or about the sites of old lakes; they sustain the conclusion that the unstratified drift was essentially a dry land deposition.

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* The existence of essentially independent glaciers, (under the continental Glacier) in the Glacial era was recognized by the author in an article in this Journal, vol. xxxv, p. 243, 1863, and in his Manual of Geology, p. 763, published about the same time; and four great glaciers were there particularly mentioned, the Connecticut River, the Penobscot, the Hudson River, and the Mohawk River.

2. The magnitude, wide distribution, and regularity of direction in the scratches are evidences against Icebergs.

This is no new argument; yet it has lost nothing of its force by long use. Broad furrows, eight to ten inches in depth, made in trap or granite over long distances, uniform in direction, must have required prolonged abrasion for scores of years, and by an abrading agent not liable to change of course through tides or currents, or to changes of form and thereby of center of gravity from waste in the waters over the rocks. Glacial abrasion has been found so generally wherever the soil has been freshly removed that it may be safely inferred, as has been done for other parts of New England, that the abrasion was universal. Passing from the New Haven region westward, over the high plateau of Litchfield, Warren, etc., 1000 to 1500 feet in height above the sea, the scratches have the same uniformity and wide distribution. Grounded icebergs would be sufficient for such results only in case they spread completely over the wide surface and rested firmly upon its every part,—in which case they would be nothing less than partly submerged glaciers.

3. The scratches are, in some cases, in such positions that only a glacier could have produced them.

For example: on Mount Carmel—an east-and-west ridge in the Connecticut valley depression, about 750 feet in height, nine miles north of New Haven—along one of the steep southern valleys, the surface of trap (dolerite) is extensively abraded, and marked with many large and broad north-and-south furrows. An iceberg, moving southward, which could float over the top of Mount Carmel ridge would not touch bottom in this southern valley, for the part eroded is at least 150 feet below the level of the ridge to the north of it. While this erosion is, therefore, beyond the capacity of icebergs, it would be the natural result of a Connecticut valley glacier.

4. Since icebergs are fragments of glaciers broken off by the sea into which they descend, and since their freight of stones is part of the moraines of the old glacier, the boulders of the New Haven region, and of New England generally, should, on the Iceberg hypothesis, be the rocks of the White Mountains (whose highest peak, Mt. Washington (the loftiest in New England) is 6288 feet high), or of some Green Mountain Peak (over a thousand feet lower), if not from some more distant northern source.

But, in fact, the boulders about New Haven have come mainly from the central part of Connecticut and Massachusetts, and largely from the hills or ledges in the Connecticut valley itself; and not from any mountain summit or ridge either side. They are therefore from *the bottom* of the alleged Iceberg sea, and not from any emerged summits.

These boulders are masses of trap 1000 tons in weight and less; and Mt. Tom and Mt. Holyoke, situated adjoining the Connecticut river in Massachusetts, seventy miles north of New Haven, are the most northerly points from which such masses could have come. The tops of these so-called mountains would have been over 2600 feet below the surface if the Iceberg sea were 4000 feet deep. Other boulders are of the Triassic red sandstone; and these also had their origin *in the Connecticut valley*, south of the northern limits of Massachusetts, for none exists farther north. Others, of large size, some of them ten to fourteen feet in length, are of gneiss and came from a gneiss region, either in northern Connecticut, ten to twenty miles west of the Connecticut river, or just north of this in the adjoining part of Massachusetts. Again, six to eight miles west of New Haven, there are numerous large boulders of porphyritic gneiss, which were derived from ledges less than thirty miles distant to the north or northwest.

The facts show, beyond question, that in the Glacial era, the transported blocks came from the comparatively low regions, in the very bottom of the supposed Iceberg sea, not far to the north of New Haven, instead of from distant and elevated heights to the northeast or northwest; and this was true of all the drift material. The observations of others over New England, as well as those I have made over Connecticut, sustain the conclusion that the sand and gravel of the unstratified drift has not come from remote points, but has been shoved southward by some agent that could gather it up over the breadth of the land and bear it onward to drop it after a few miles, or scores of miles of transportation. All this is evidently impossible work for icebergs.

Since, then, icebergs cannot pick up masses tons in weight from the bottom of a sea, or give a general movement southward to the loose material of the surface; neither can produce the abrasion observed over the rocks under its various conditions; and inasmuch as all direct evidence of the submergence of the land required for an iceberg sea over New England fails, the conclusion appears inevitable that icebergs had nothing to do with the drift of the New Haven region, in the Connecticut valley; and, therefore, that the Glacial era in central New England was a *Glacier* era.

ART. II.—*On the Corona seen in total Eclipses of the Sun;* by Professor W. A. NORTON.

IN a communication to the Sept. No. of this Journal, I alluded briefly to the auroral theory of the solar Corona, and referred to publications in which I had advocated it. I propose now to give a brief discussion of the theory.

The grounds upon which I have maintained the auroral origin of the Corona in different publications are the following:

1. The Corona cannot be the permanent atmosphere of the sun, shining by reflected light, since its outline is neither circular nor oval, but exceedingly irregular, and it extends out from the sun many times farther in some directions than in others. The utmost that can reasonably be maintained is that for a small portion of its outward extent, for which the gradation of light is nearly uniform, it may possibly be a solar atmosphere.

2. The natural indications of the aspect of the corona are that it is chiefly composed of separate masses of luminous matter, of unequal brightness and length, radiating out from different points of the sun's limb. The general radiated structure of the corona, and the great comparative outward extent of the luminous radiations in certain directions, have attracted the attention of the observers of all modern eclipses. Some streamers have been seen to extend more than 1,000,000 miles from the sun, while others did not extend to one quarter of this distance.

3. Reasoning analogically from the earth to the sun we naturally conceive the body of the sun to be surrounded by a permanent atmosphere. On the same grounds we should infer that the space exterior to this atmosphere is pervaded, either occasionally or permanently, by auroral streamers, similar to those which at times shoot out many hundreds of miles into space, from the upper atmosphere of the earth.

4. If the luminous radiations of the corona are in fact auroral streamers, we must expect that they will not be permanent in their extent and position. Now it is well known

that such is the fact, for the aspect of the corona has been very different in different eclipses (e. g. eclipses of 1842, 1851, 1858, and 1860). It has even been maintained by some observers that the rays of the corona had a flickering luster, and varied in extent and position during the short period of a single eclipse.

5. Admitting, as we must, the actual radiated structure of the corona, its individual streamers, or luminous radiations, may be conceived either to be permanently connected with the sun, or to be composed of luminous matter actually streaming away from the sun, to an indefinite distance, into space. If we adopt the former idea, we virtually admit that a permanent vaporous atmosphere of sensible density extends from the body of the sun to a distance greater than the sun's diameter, a position that cannot with any plausibility be maintained.* In support of the other hypothesis we have the well established fact that some form of luminous matter, belonging to cometary bodies, when it comes under a certain degree of influence from the sun, is projected or in some manner detached from the nuclei of these bodies, and repelled from the sun, and under the operation of the solar repulsion urged away from them to an indefinite distance, forming the luminous trains by which they are attended. (See the author's papers on Donati's Comet published in this Journal, Jan. and May, 1860, and July, 1861; and the discussion of the Dynamical Condition of the Head of a Comet in the No. for Jan., 1859). To suppose that the rays of the corona are actual radiations of luminous matter, is only to suppose that a portion of the photospheric matter of the sun becomes subject to the operation of the same forces, that we perceive the sun to exert upon a portion of the matter of comets. The luminosity of such radiations may be ascribed either to a reflection of the sun's light, or to electric discharges. Upon this question we shall see important evidence was obtained at the total eclipse of Aug. 7, 1869.

6. If we adopt the auroral theory of the corona, and at the same time admit that the auroral streamers are actual emanations of luminous matter, the following consequences may be expected to follow.

(1.) A portion of the auroral matter emitted from the sun should fall upon the earth's atmosphere, and may furnish the substance of terrestrial auroras, for which no terrestrial origin has yet been detected.

(2.) Upon this view of the possible origin of terrestrial auroras, the close correspondence that has been detected between the periods of the sun's spots and of auroras, should subsist if we allow that the spots are merely the natural result of the supposed discharges of the solar matter, prevailing for a time at certain points of the photosphere; or indeed if we grant that they are in any way the result of these discharges visible in the corona.

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* According to the recent spectroscopic determinations of Lockyer and Frankland, the solar atmosphere must be of exceeding tenuity in the region of the rose-colored protuberances just above the general surface of the chromosphere.

(3.) In the wave propagation of the impulsive actions on the ether of space, of the electric discharges to which we may ascribe the material emanations from the photosphere, and in the electric and magnetic phenomena attendant upon the reception and accumulation of the solar auroral matter in our atmosphere, we have a plausible general explanation of the periodic and irregular disturbances of the magnetic condition of the earth, and of their known physical relations to the sun's spots. This theory of the origin of the diverse perturbations of terrestrial magnetism I have elaborated, and followed out into a detailed discussion of the variations of the different magnetic elements in former Nos. of this Journal (viz: for March and July, 1855).

We may add that it derives additional support from the general result arrived at by Prof. Chambers, in his discussion of the "Nature of the Sun's Magnetic Action," viz: that "the mode in which forces originating in the sun, influence the magnetic condition of the earth, is not analogous to the action of a magnet upon a mass of soft iron placed at a great distance from it, but that these forces proceed from the sun in a form different from that of magnetic force, and are converted into this latter form of force probably by their action upon the matter of the earth or its atmosphere." If this be admitted then we must conclude that the perturbations of the earth's magnetic condition, as evinced by the variations of the position and directive force of the magnetic needle, must result either from some action direct or indirect on the earth or its atmosphere, of some form of matter emitted from the sun, or from a wave-action propagated from the sun, or from both of these operative causes combined.

(4.) The streamers of the corona should have at different points of the sun's photospheric surface different directions, parallel to the diverse directions of the magnetic force of the sun at this surface. These directions should be variously inclined, in different heliographic latitudes, to the horizontal lines at the points of the surface, and also to the plane of the sun's equator; like the dipping needle on the earth and the streamers of a terrestrial aurora. In low latitudes the angles of inclination to the plane of the equator should be large, and the streamers proceeding from corresponding points in the two hemispheres, should converge and intersect in the plane of the equator. In proportion as these corresponding streamers proceed from points more remote from the sun's equator, they will intersect under a smaller angle, and their point of intersection will be more distant from the sun's surface; until at the heliographic latitude of 30° to 35°, they will become parallel to the plane of the equator. Those emanating from still higher latitudes will diverge from the plane of the equator and from each other.*

If these facts be attentively considered it will be seen that the result should be the formation of a luminous appearance extending indefinitely outward from the sun into space, and elongated in the plane of his equator; and that to observers on the earth it would have an apparent form more or less triangular.

The same fundamental conception which accounts for the solar corona, and the physical relations known to subsist between the sun's spots and terrestrial auroras, as well as between these spots and the varied magnetic disturbances occurring on the earth, furnishes then an adequate explanation of the extent, form, and position of the *Zodiacal Light.* In fact we see that the zodiacal light is but the indefinite extension of the corona.

We have here tacitly supposed that the solar emanations consist of magnetic matter projected with great velocity into space, in the directions of the prolongations of the auroral columns, and proceeding on indefinitely in these directions; but if, like the cometic matter, they are exposed to a continual repulsion from the sun, the paths described by the receding particles would be hyperbolas convex toward the sun. The point of intersection of any two streamers proceeding from corresponding low latitudes in the two hemispheres, would in consequence be thrown to a greater distance from the sun, but the general result as to the form and position of the luminous appearance produced, (the zodiacal light) would be the same.

In support of this view of the origin of the zodiacal light we may state that Cassini drew from his observations on the sun's spots and the zodiacal light, made during the interval from 1665 to 1688, the conclusion that a physical connection subsisted between these two phenomena, and that the substance of the zodiacal light was in fact some emanation from the sun's spots. Again, according to Arago, it appears from the entire series of observations at Paris and Geneva, that the zodiacal light varies considerably from one year to another, and that the observed variations cannot result entirely from changes in the transparency of the atmosphere. We shall soon see that the form of the corona, as seen in the eclipse of 1869, and previous eclipses, presented certain prominent features that accord with the theoretical conclusion that the zodiacal light is but the indefinite extension of the corona.

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* It is here assumed that the magnetic equator of the sun is coincident with his heliographic equator.

It is proper to state here, that in what precedes we have really been contemplating but different sides of one comprehensive theory, which embraces a connected series of solar phenomena, of which the corona is but one term. The outline of this theory is given in the author's Treatise on Astronomy, revised edition (1867). It is that a portion of the matter of the sun's photosphere is in the habitual condition of auroral magnetic columns; that by electric discharges along these columns, their substance becomes dispersed and in part projected into space; and that this process, wherever occurring, may by a continued dissipation of a portion of the photospheric matter at that locality, eventuate in the formation of a visible spot on the disc; that the photospheric matter thus discharged into space, is in that peculiar condition recognized in cometic matter in which it becomes subject to a repulsive action from the sun (or else to a diminished attractive action, as occurred to a certain extent in the case of Donati's comet, and in that of 1861), and in the act of flowing away is visible in solar eclipses as the streamers of the corona, and at more remote distances as the zodiacal light; that these solar emanations furnish the matter of terrestrial auroras, and when descending in copious showers into the earth's atmosphere, and developing electric currents and disturbing the magnetic condition of the earth, are the determining cause of all the phenomena of "magnetic storms." The apparent structure, and variability of the corona, and, as we shall soon see, the most characteristic features of its form, the form, position, and variability of the zodiacal light, the coincidence of the periods of the sun's spots with the periods of terrestrial auroras, and with those of the perturbations of the magnetic needle, all accord with this general theory. I have also endeavored to show in my papers on the variations of the magnetic elements, that these variations are such as should naturally result from the electric currents in the upper atmosphere, (or what may be called the photosphere of the earth), that would ensue from the reception of the supposed impulsive waves, and material emanations proceeding from the sun. (See this Journal, II, vol. xix, March and July, 1855).

If it indeed be true, that from the fundamental conception of material emanations from the sun similar to those which we know to take place from the head of a comet under the influence of the sun, a connected series of phenomena may be theoretically deduced which have their actual counterparts in Nature, it must be conceded that there is a high probability that this conception is founded in truth, and furnishes the true explanation of the varied phenomena observed.

Results of Observations on the Corona made at the Total Eclipse of August 7, 1869.

The observations made on the Corona on the occasion of the eclipse of 1869, have furnished several striking confirmations of the theory that it is an auroral phenomenon.

1. *The observed form and structure of the Corona.*—I will first adduce the results of my own observations. These were made at Des Moines, Iowa, with the naked eye, and a good opera-glass, and were chiefly confined to the Corona. When the totality commenced, and the beautiful corona stood revealed, like a new creation, against the dark background of the sky, almost the first striking feature that caught my attention was the great inequality in the extent of its outstreaming in different directions, and its consequent irregularity of outline. This outstreaming or luminous radiation, was particularly conspicuous from the eastern limb, *nearly in the direction of the plane of the ecliptic or the sun's equator.* It could be distinctly traced in that direction to a distance from the sun equal to his own diameter. For an extent of some 15° on either side of the ecliptic, individual hair-like streamers, seemingly nearly parallel to the ecliptic, extended out a large fraction of this distance. From the opposite limb, and in the opposite direction, the coronal streamers were conspicuous, but of less extent than in the direction of the ecliptic toward the east. From the polar regions other pointed masses of light extended out to considerable distances, but not so far as those just noticed. They seemed to be composed like the others, of rays or hair-like luminous radiations, more or less distinct. The separate luminous lines appeared to Professor Eastman, from the U. S. Naval Observatory, (who observed the corona at the same station, through a small telescope) to converge more or less. This convergence I failed to detect; but I distinctly noticed that the outstreaming mass from near the north pole of the sun had approximately the form of a triangle with curved sides, convex outward, but the triangular outline appeared as if resulting from the intersections of individual radiations, rather than as being the definite boundary of a stationary luminous mass.

The corona had a white silvery luster, and appeared at times suffused with a delicate rosy tinge, but this was probably a subjective effect. No flickering or variation of the luster of the corona, was observable during the totality. Nor was there any noticeable change in its general form, or in the extent of its luminous radiations, though I carefully watched for such changes. Dr. B. A. Gould, who was stationed at Burlington, Iowa, and other observers, thought that both the luster and extent of the radiating masses, or "star points," underwent material variations. A similar difference of opinion is found in the reports of observations on previous eclipses. If variations in the brightness and extent of the coronal radiations do actually occur, it is favorable rather than opposed to the auroral theory of the corona; but it is probable that the apparent changes are due to inequalities in the interceptive action of the earth's atmosphere on the light of the corona, and especially on the faint light at its outer boundary.

Professor Harkness, of the U. S. Naval Observatory, in his able Report of Observations on the eclipse, states that the four angles of the trapezoidal outline of the corona were in the middle heliographic latitudes—relying upon the report of another observer; but on a direct examination of the question of the location of these angles, or "star points" of the corona, made since the publication of the Report, he has satisfied himself that their actual position was such as I have above reported it from my own observations.*

In the delineations of the corona given by the observers of previous eclipses, two or more conspicuous outward extensions are generally shown, but the positions of these more projecting parts are seldom given with respect to the equator or poles of the sun. The figure of the eclipse accompanying the Report of P. Prof. Capellotti, of observations on the eclipse of April 15, 1865, made at Chili, is an exception. It shows three principal points of outstreaming of the corona; two lying very nearly in the plane of the sun's equator, and nearly diametrically opposite to each other, and a third near one of the poles of the sun. In the eclipses of 1858, 1860 and 1868, four such points were seen, distributed at about a quadrant's distance from each other. In the eclipse of 1842, but two were noticed, which were diametrically opposite to each other. In that of 1851, there appears to have been no marked deviation from a general uniformity of radiation.

Relying then upon the only definite knowledge we have of the location of the more conspicuous portions of the corona, viz. that obtained in the eclipses of 1865 and 1869, we may say that the corona is brighter and more extended about in the direction of the plane of the sun's equator than in any other direction. This striking fact lends a powerful support to the auroral theory of the corona; for, as we have already seen, the streamers proceeding from the lower latitudes on the sun, on opposite sides of the equator, should converge and intersect in the plane of the equator, and for a certain distance on either side of this plane, and in consequence the corona should appear to extend farther in the plane of the equator, than in other directions. The convergence of individual rays or lines of emanation, we have already seen, was actually noticed by Professor Eastman. It of course may happen that inequalities in the amount of outstreaming on opposite sides of the equator, may throw the more prominent and conspicuous parts of the corona to the one side or the other of the plane of the equator. It will be observed that from our present point of view, the extension of the corona in the plane of the sun's equator is a phenomenon kindred to the much greater luminous extension seen in the zodiacal light; the only difference between them being, that in the former the auroral emanations proceed from lower heliographic latitudes, and intersect nearer the sun.

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* Professor Winlock, in his report of observations on the eclipse, says, "the photograph of the corona taken at Shelbyville shows a flattening at the extremities of the sun's axis, and an elevation about the equatoreal region." The photographic impressions obtained of the eclipse, at the different stations show, however, but a small portion of the outward extent of the corona visible to the naked eye.

But it may be asked how are we to explain, on the present theory, the "star points" of the corona over the polar regions of the sun. For these, two reasons may be assigned. (1) If we admit a distribution of magnetism on the sun similar to that which prevails on the earth, the auroral streamers should diverge from each other less rapidly in the high than in the low latitudes. (2) Upon opposite sides of a line of no declination traversing the sun's surface, analogous to that which traverses Russia, the natural directions of the streamers prolonged upward would be such as to occasion the convergence and intersections of those proceeding from the opposite sides of this line.

We may say then that the more extended portions of the corona, in the eclipse of 1869, were over those regions of the sun's surface, and those only, where upon the present theory the intersections of streamers might be expected to occur.

In some eclipses distinct luminous curves having the appearance of luminous jets issuing tangentially to the sun's limb, or obliquely inclined to it, and pursuing a course either convex or concave to the limb, have been seen. According to M. Liais these peculiarities were conspicously observable in the eclipse of Sept. 7, 1858. While it is possible that such curves may be the result of the intersections of a mass of straight streamers, it is not improbable that they may be actual luminous jets; for if from any cause any portion of the auroral matter should be projected from the sun in a direction oblique to the surface, it would proceed in a convex hyperbolic curve if repelled by the sun, and in a concave curve if attracted. Now I have shown in a former No. of this Journal (July, 1861), that the portion of cometary matter posited on the convex side of the tail of Donati's Comet was actually repelled by the sun, while that on the concave side had become detached from the head of the comet, because of a diminished gravitation toward the sun. Upon our fundamental conception that the coronal matter is essentially in the same physical condition as such cometic matter, and subject to the action of the same solar forces, it may well happen that some individual jets will proceed in convex, and others in concave curves, according as the escaping matter is repelled or attracted by the sun.

2. *Observations on the physical constitution of the corona with the Spectroscope and Polariscope.*—The results of the observations made at the late eclipse, with the spectroscope and polariscope, are strongly confirmatory of the truth of the theory of the corona under discussion. Professor Pickering in the Report of his observations with a polariscope, says, "The form of polariscope used was that adopted by Arago in his experiments on sky polarization. It consists of a tube about twenty inches long and two inches in diameter, one end of which is closed by a double image prism of Iceland spar, and the other by a plate of quartz. Looking through the former we see two images of the latter, which when the light is polarized assumes complementary tints. If, now, the corona was polarized in planes passing through the center of the sun (as is generally admitted), when viewed through the polariscope, in one image the upper and lower parts should have appeared blue, and those on the right and left yellow; while in the second image these colors would be reversed, the yellow being above and below, and the blue on the sides. In reality the two images were precisely alike, and both pure white, but one was on a blue and the other on a yellow back-ground. From this we infer that the corona was unpolarized, or, at least, that the polarization was too slight to be perceptible."

We may infer from this that the corona is either self luminous or shines by diffuse reflection; since specular reflection produces polarization.*

The testimony of the spectroscope is still more decisive. Profs. Pickering, Harkness, and Young, agree that the spectrum from the light of the corona was a continuous one, or free from dark lines; but containing one or more bright lines. The absence of dark lines indicates that the corona did not shine by the light of the photosphere, reflected either diffusely or specularly from its substance; since such light, after reflection, should, like the direct solar light, have given a spectrum with the Fraunhofer lines. The presence of bright lines, on the other hand, is a direct indication that the corona was self luminous; and therefore that its light was the result either of com-

* The question whether the light from the corona is in any degree polarized or not cannot be regarded as definitively settled. It is to be hoped that the observations to be made on the eclipse of December will remove all doubt on this point.

bustion or of electric discharges. As it is hardly supposable that an actual combustion could prevail at the distance of tens, and hundreds of thousands of miles from the sun's photosphere, in regions where, if any solar atmosphere exist, the results of recent observations with the spectroscope by Lockyer and Frankland lead us to believe that it can only be the faintest possible trace of it, we must infer that the light of the corona is of electric origin.

In the hands of Prof. Young and Prof. Winlock the spectroscope has obtained direct evidence of a physical correspondence between the solar corona and terrestial auroras. Prof. Young observed in the spectrum of the corona a bright line the position of which he gives as 1474 on Kirchoff's scale, and which proves to be in coincidence with a small line marked as *iron* on Kirchoff's and Angström's maps. He remarks that "it turns out also to coincide very closely if it is not (which is much more probable) absolutely identical with a line recently discovered by Prof. Winlock of Cambridge, in the spectrum of the aurora borealis. He also saw two other fainter lines in the spectrum of the corona which coincided quite closely with other lines reported by Prof. Winlock as visible in the spectrum of the aurora. In view of these results of spectroscopic observation he remarks, as follows: "At present it seems pretty likely that the spectra of the corona and the aurora borealis are identical, with only such differences in the intensity of their lines as we might naturally expect, and that very probably the identity extends to the essential nature of the phenomena themselves."

The detection of the same iron line in the aurora and corona, taken in connection with the well established fact that the vapor of iron is present in the photosphere and chromosphere of the sun, and that the magnetic features of the aurora lead to the natural conclusion that some form of ferruginous matter constitutes the substance of auroras, for which no terrestrial origin can reasonably be assigned, conducts to the inference that the terrestrial auroral matter is derived from the sun, and adds to the weight of accumulative evidence in support of the theory I have advocated that the corona is made up of material emanations from the sun.

NOTE.—Some persons have conjectured that the corona might be produced by the passage of the sun's rays through the earth's atmosphere, but it may readily be shown that this is impossible. When one reflects that the half width of the moon's shadow, in the larger eclipses, is as great as the estimated height of the atmosphere, it will be seen that, to an observer on the central line of the eclipse the line of sight will not fall upon the illuminated portion of the atmosphere exterior to the shadow, unless inclined under a large angle to the line of direction of the centers of the sun and moon. The corona, therefore, if of terrestrial atmospheric origin ought to present, toward the middle of the eclipse, the appearance of a halo *entirely detached from the dark body of the moon, and many degrees distant from it.* It ought also to increase in brightness from its inner border, for a considerable distance outward.

Others have imagined that the corona might be attributable to the passage of the sun's light through a lunar atmosphere; but since some of the streamers, or rays of the corona, have been seen to extend to a distance greater than the sun's diameter, this would require the lunar atmosphere to be of vast extent; whereas no decisive evidence has yet been obtained of the existence of any lunar atmosphere capable of producing a sensible refraction, or reflecting a perceptible amount of the sun's light to an observer on the earth.

Perhaps the more prevalent idea, at the present day, is that the corona, with its rays and tufts of light, is a phenomenon of diffraction produced by the passage of the sun's rays along the denticulated edge of the moon. This theory has an air of plausibility, but it is entirely inadequate to account for the great extent of the coronal rays. The fringes produced by the diffraction of light in its passage near the edge of a body appear to the eye of the observer to extend but a small angular distance from the edge. This would be more strikingly true in the case of a distant body, like the moon.

The only remaining supposition is that the corona is either an envelope of some kind permanently connected with the sun, or is made up of material emanations proceeding immediately from the sun. To the large body of indirect evidence *that the corona is wholly a solar phenomenon* that has been obtained, we may now add that of direct observation, since it appears that "an examination of the photographs of totality," obtained at the eclipse of 1869, shows that as the moon advanced the corona was progressively covered.

ART. III.—*On the Duration of Flashes of Lightning*; by O. N. ROOD. (From a letter to Dr. W. GIBBS.)

AFTER the completion of my first set of experiments on the duration of the discharge of a Leyden jar, I became anxious to make some measurements of the duration of a flash of ordinary lightning, which may be considered as equivalent to the discharge of an immense jar with an enormous striking-distance. The results of Feddersen have shown that the duration of the discharge is increased by an addition to the size of the jar, as well as by augmentation of the striking-distance, and as both these quantities are so large with a flash of lightning, it was reasonable to expect that the duration of its discharge would be prolonged in some corresponding ratio. During the violent thunder-storm of last August, which occurred in the evening, I happened to be at a house commanding an unobstructed view of the horizon, and this circumstance taken in connection with the frequency and proximity of the electrical discharges, induced me, although entirely unprovided with apparatus, to attempt a measurement of their duration. A circular disc, five inches in diameter, was hastily cut from white cardboard, while a steel shawl-pin served as an axis, on which it was made to revolve by constantly striking its edge tangentially with the right hand, the pin being held in the left. The *maximum* velocity attainable in this way was always employed. The general indications at the time were that the rate thus obtained was considerably more uniform than might have been expected, and subsequent quantitative experiments have confirmed this idea. The first experiments were made by observing black figures traced near the circumference of the disc, which was illuminated solely by the rapidly recurring flashes, and it often happened that the figures, with their details, were seen quite as clearly and sharply as though the disc had been stationary; on the other hand, sometimes the edges seemed blurred, as though the disc had moved through a few degrees during the act of discharge. The result being doubtful, the mode of experimenting was quickly changed; about fifteen narrow radial apertures were made near the circumference of the disc, and the flashes and illuminated clouds were observed through these openings, the disc being made to revolve as before. The distance of the eye from the apparatus was about eight inches, and it was of course adjusted so as to obtain distinct vision of the disc. The result was that sometimes the openings were seen quite unchanged in appearance, but more frequently they were most distinctly elongated into well defined streaks some degrees in length. They were observed often and without difficulty, but as farther confirmation I may add that I requested Prof. Joy, who was ignorant of the actual form of the aperture, to state his opinion of their apparent shape while the disc was in rotation. The reply was that they resembled Prince Rupert's drops—a not unfair description of the phenomena in question. Repeated estimates of their size were then made with paper and pencil. Some time afterward I measured the velocity which I could communicate to this disc in the manner above described, by attaching to it a small hollow axis through which the steel pin passed, the disc being then caused to wind up a thread stretched by a small weight. The rate of rotation thus attainable was found to be about twelve revolutions per second, which is a little more than I had anticipated. The average size of the streaks was 9°, corresponding to a duration of $\frac{1}{480}$ of a second. It hence results that the duration of the flashes of lightning on the occasion referred to was in round numbers about $\frac{1}{500}$ of a second, some of them, however, seeming to be confined to smaller limits.

I know of only a single circumstance which might militate against the correctness of the above conclusion, and it is but fair to give it such weight as it may carry. Becquerel has succeeded with some difficulty in observing a faint phosphorescence when an electric discharge is passed through rarefied air, and it is not absolutely impossible that the effects observed by me were due to a cause of this kind.

This point can hereafter readily be decided by observing with a revolving disc, not the distant clouds, but a sheet of white paper, placed so as to receive the light from the electrical flashes.

Columbia College, Nov. 10th, 1870.

ART. IV.—*On the physical condition of a closed circuit contiguous to a permanent and constant Voltaic current; or, on "the electro-tonic state;"* by ALFRED M. MAYER, Ph.D.

IN 1831, after Faraday had made his brilliant and unequaled discoveries of Voltaic and magnetic induction, he gave, in his first series of experimental researches, a section on a "New electrical State or Condition of Matter;" which he designated as the *electro-tonic* state. This can, in a few words, be explained as a certain state of electrical tension produced in a closed metallic circuit by the proximity of another circuit, through which circulates an electric current. The latter circuit being broken, this tension evinces itself in producing, during its disappearance, an electric wave in the closed circuit, similar in character, but opposite in direction, to the one produced on forming the contiguous electric current.

Faraday, with his habitual philosophic reserve, hesitating to give a formal enunciation of any hypothesis as to the electrical or molecular condition of the wire during this state, says, (Exp. Res. 71) "this peculiar state appears to be a state of tension, and may be considered as *equivalent* to a current of electricity, at least equal to that produced either when the condition is induced or destroyed." But in the celebrated Bakerian lecture which he delivered in Jan., 1832, he reluctantly releases his mind from this opinion, and says, (Exp. Res. 231; 242), "The law under which the induced electric current excited in bodies moving relatively to magnets, is made dependent on the intersection of the magnetic curves by the metal being thus rendered more precise and definite, seem now even to apply to the cause in the first section of the former paper; and by rendering a perfect reason for the effects produced, take away any for supposing that peculiar condition which I ventured to call the electro-tonic state. * * * * Thus the reasons which induce me to suppose a particular state in the wire have disappeared; and though it still seems to me unlikely that a wire at rest in the neighborhood of another carrying a powerful electric current is entirely indifferent to it, yet I am not aware of any distinct *facts* which authorize the conclusion that it is in a particular state."

In Dec., 1834, however, we see with what reluctance he gave up his first opinion, for he thus writes (Exp. Res. 1114) in reference to "the influence by induction of an electric current on itself, and on the inductive action of electric currents generally." "Notwithstanding that the effects appear only at the making and breaking of contact, (the current remaining unaffected, seemingly, in the interval), I cannot resist the impression that there is some connected and correspondent effect produced by this lateral action of the elements of the electric stream during the time of its continuance. An action of this kind, in fact, is evident in the magnetic relations of the parts of the current. But admitting (as we may do for the moment) the magnetic forces to constitute the power which produces such striking and different results at the commencement and termination of a current, still there appears to be a link in the chain of effects, a wheel in the physical mechanism of the action, as yet unrecognized." Again, in 1838, (Exp. Res. 1661) he recurs to the idea of the electro-tonic state, in speaking of "the transverse effect of a current;" and in his "Relation of the electric and magnetic forces" (Exp. Res. 1729) he states, "It appears to me possible, therefore, and even probable, that magnetic action may be communicated to a distance by the action of the intervening particles, in a manner having a relation to the way in which the inductive forces of static electricity are transferred to a distance; the intervening particles assuming for the time more or less of a peculiar condition, which, (though with a very imperfect idea) I have several times expressed by the term *electro-tonic state.*"

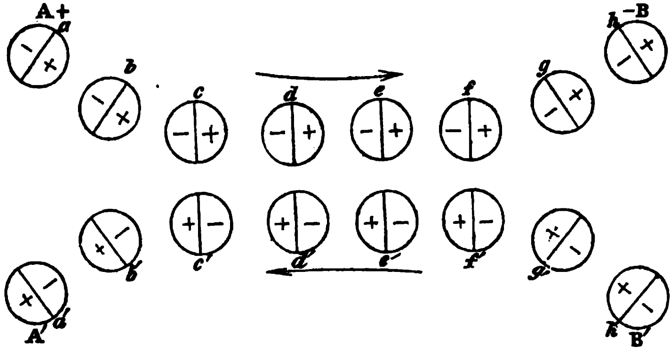
As late as 1851, Faraday yet hopes that future research may verify his idea of the electro-tonic state, for in his paper "on the lines of magnetic force," after having shown the relation of the magneto-electric current to the electro-conducting power of the substance in which it is induced, he writes (Exp. Res. 3172–73), "All the results described are those obtained with *moving metals.* But mere motion would not generate a relation, which had not a foundation in the existence of some previous state; and therefore the *quiescent* metals must be in some relation to the active center of force, and that not necessarily dependent on their paramagnetic or diamagnetic condition, because a metal at zero in that respect, would have an electric current generated in it as well as the others. The relation is not as the attractions or repulsions of the metals, and therefore not magnetic in the common sense of the word; but according to some other functions of the power. * * * * * If such a condition be hereafter verified by experiment, and the idea of an electro-tonic state be revived and established, then, such bodies as water, oil, resin, &c., will probably be included in the same state; for the non-conducting condition, which prevents the formation of a current in them, does not militate against the existence of that condition, which is prior to the effect of motion. *A piece of copper,* which cannot have the current, because it is *not in* a *circuit,* and a piece of lac, which cannot, because it is *a non-conductor* of electricity, may have peculiar but analogous states, when moving across a field of magnetic power."

In his paper on the physical character of the lines of magnetic force, occurs this remarkable paragraph (Exp. Res. 3269): "The mutual relation of the magnetic lines of force and the electric axis of power has been known ever since the time of Œrsted and Ampère. This, with such considerations as I have endeavored to advance, enables us to form a guess or judgment, with a certain degree of probability, respecting the nature of the lines of magnetic force. I incline to the opinion that they have a physical existence correspondent to that of their analogue, the electric lines; and having that notion, am further carried on to consider whether they have a probable dynamic condition, analogous to that of the electric axis to which they are so closely, and, perhaps, inevitably related, in which case the idea of magnetic currents would arise; or whether they consist in a state of tension (of the æther?) round the electric axis, and may therefore be considered as static in their nature. Again and again the idea of an *electro-tonic* state has been forced on my mind; such a state would coincide and become identified with that which would then constitute the physical lines of magnetic force."

We see from the above extracts (all that refer to this subject) that Faraday never gave a formal statement of his conception of the physical condition constituting the electro-tonic state; but other electricians, including Weber, Neumann and A. De la Rive, have framed hypotheses, more or less probable, to explain this condition. The one most generally received, and indeed widely copied into existing treatises on physics, is that of A. De la Rive. (Traité d'Electricité, t. i, p. 445). I here give this in his own words; and will then describe certain experiments of precision, which I have made to test the truth of his hypothesis. This is the object of making this communication.

"Without having recourse to conceptions and calculations as profound as Weber and Neumann's, I think that we can consider induction as the result of the ordinary inductive decomposition of the natural electricity of each particle of the induced conductor, by the already separated electricities of each corresponding particle of the inductor. In order that this shall take place, we must admit that the propagation of the current takes place by a series of decompositions and recompositions of the electricities of the successive molecules, in the same manner as takes place with insulating bodies, (referring to Faraday's theory of inductive action).

"Let A B be a conductor traversed by a current in the direction from A to B; the successive particles of which it is composed have their natural electricity decomposed, the − turned towards A where is the positive pole of the apparatus, and the + turned towards B where is the negative pole. The electricities, as soon as they have been separated, combine from particle to particle, thus: the negative of *a* with the positive of the pole A, the negative of *b* with the positive of *a*, and so on to the positive of *h* which combines with the negative of the pole B.



This recomposition, which is instantaneous, is immediately followed by a new decomposition, and this by a recomposition, and so on. This succession of decomposition and of recomposition is so rapid, that there is always, as experiment shows, an electric tension in each particle of the conductor, so that we can consider that the state in which it is represented in the figure, which we will call *state of polarization*, is nearly permanent.

"Now let A′B′ be a second conductor similar to the first, as near to it as possible, and insulated with silk or wax. At the moment we pass a current in A B, and where consequently we polarize its particles, we produce in A′B′ an opposite molecular polarization, the + of each particle being opposite the − of each particle of A B and the − before the +. It thereby follows that if, at the moment when A B is traversed by a current, the two extremities of A′B′ are united by a conductor, such as the wire of a galvanometer, the + of the molecule *a′* combines, through this conductor, with the − of the molecule *h′*, and this produces an instantaneous current directed from A′ to B′ in the conductor, and from B′ to A′ in the wire A′B′ itself, that is to say in a direction contrary to the inducing current. Also, if instead of being united by a conductor, the extremities A′ and B′ communicate with the two plates of a condenser, A′ will give it a charge of positive electricity, and B′ one of negative. As soon as *a′* has lost its positive electricity and *h′* its negative, the negative of *a′* is then disguised by the positive of *b′*, and so on to the negative of *g′*, which is disguised by the positive of *h′*; these electricities do not neutralize each other, because they are retained by the opposite electricities of the particles of A B; but if at the instant that the current ceases to pass in A B, the two extremities of A'B' are united by a conductor, the negative electricity of a' unites with the positive of h', and at the same time the contrary electricities of each of the particles of a', b', c', d', e', f', g' combine, and thence there results a current which progresses in the conductor from B' to A' and from A' B' in the wire A'B' itself. Thus A'B' is traversed, in this case, by a current directed in the same direction as the inducing current. The state of electric tension which exists in the wire A' B' whilst the current traverses A B is that which Faraday has called *electro-tonic;* and the cessation of that state produces the second current of induction, while its creation produces the first. * * * * In reality in the above theory which we have given, the production of the two instantaneous induced currents is altogether similar to that which passes in the charging and discharging by cascade of several consecutive Leyden jars, in which the inner coating of each communicates with the outer coating of the preceding one." De la Rive then shows how this hypothesis is applicable to the explanation of the production of induced currents, by the approach and recession of a current in reference to a closed circuit; to the production of induced currents by magneto-electric currents; and to all the facts embodied in Lenz's laws.

It appears to me that the truth of the above hypothesis can be tested in the following manner. A closed metallic circuit (which we will call the secondary wire), is in proximity to a wire carrying a voltaic current, (which we will call the primary wire), which produces in the former powerful induced currents, on making and breaking battery contacts. While in these circumstances, we pass through the secondary wire a direct current, and measure with precision its intensity; then an *exactly equal* current is passed in an inverse direction, and its intensity measured. Now, if as De la Rive supposes, the secondary wire be in a state of polarization like in character but inverse in direction to that produced in the primary by the passage of the current, there will be a diminution in the intensity of the current which traverses the secondary wire in a direction opposed to this polarization, while that traversing it in the direction corresponding to this polarization, will have the same intensity as when it traverses the secondary wire, when the primary current is not in its proximity.

Four conditions have to be fulfilled in the above experiments. First, a strong inductive action must be brought to bear upon the secondary wire; 2dly, this action must be produced by a constant current; 3dly, the secondary wire must be a good conductor, and therefore cannot have in its circuit a liquid battery, wherewith to propagate the current in this wire; 4thly, a means must be devised of producing at will, in the secondary wire, a current or wave of electricity which shall always have the same intensity. The following apparatus combines these requirements in an eminent degree. Twenty-five spirals (such as are described in my papers in the Sept. and Nov., 1870, Nos. of this Journal) were placed between twenty-five similar spirals, so that each alternate spiral belonged to the same circuit. The terminals of the first series of spirals were connected with a galvanic battery, while those of the second combination were connected with a spiral similar to one of those described in the paper "on the measurement of electrical conductivities," in the Nov., 1870, No. of this Journal. This spiral was placed on a magnet, about 3 ins. distant from its end, so that by suddenly slipping it off a current could be produced in the secondary wire without the interposition of a liquid. By interchanging the connections of the terminals of this spiral, an inverse current could be produced on sliding it off. A reflecting-galvanometer, reading deflections to 15″, was also placed in the above circuit.

If the spiral is always removed from the same length of magnet with the same velocity, it necessarily follows—the circumstances in each case being alike—that successive currents of equal intensity will traverse the secondary wire. This constancy of velocity in all the experiments can be produced in the following manner. The magnet was placed vertically, N. pole downward, and the terminals of the spiral, which were 18 ins. in length, were connected with the ends of a cylinder of copper, transversely divided by an insulating disc of ebonite. Each end of this horizontal cylinder rested on a V, and a close contact was ensured by amalgamation. The spiral was now allowed to fall off the magnet, and as it always made this movement with the same velocity, it followed that currents of equal intensity were produced during each fall. It was however found that currents of such equality of intensity were produced, by *quickly* slipping off the spiral, that the range of their differences did not exceed 20″ in the deflection of the needle of the reflecting-galvanometer. In the experiments which follow, I used the currents produced by quickly removing the spiral from the magnet. This ready method of producing at will an electric current or wave of any required intensity, seems to me will be of value in many electrical researches, for I have found that any current, produced by chemical means, fails in constancy when its intensities are measured by a reflecting-galvanometer, though by the ordinary instrument it may appear so.

In the apparatus thus arranged we have a combination of 25 spirals, containing 367 feet of $\frac{1}{16}$ inch copper wire, in proximity to a combination of 25 similar spirals. A current was passed through the first spirals, of such a strength that the resistance in the battery equalled the outside resistances in the spirals, &c.

After the violent action at the galvanometer produced on making contact at the battery had subsided, and the needle was at rest, its position was determined. The spiral on the magnet was now slipped off, and the deflection of the needle precisely observed. The battery current was now broken; the connections of the terminals of the spiral interchanged, and contact at the battery formed. The spiral was now again removed from the magnet, and the deflection measured. It was found that the deflections of the needle in the first and second experiments gave (for the mean of 6 experiments of each) angles sensibly equal, and that with a galvanometer reading with precision, a deflection to 15″, and whose needle made about three vibrations per minute. These experiments were many times repeated with the current of the battery reversed in the primary spirals as well as in the magneto-current in the secondary spirals, and always with the same results.

Therefore this fact (irrespective of any theoretical consideration) is established:—*that a definite electric current, traversing a metallic circuit in proximity to another traversed by a powerful voltaic current, has the same intensity whether passed in the same direction as the latter or in a direction opposed to it.* There is, however, no doubt, a diminution in the *velocity* of this current similar to that observed in submarine cables; and it will be interesting and important to ascertain whether that velocity is the same in a direct as in an inverse direction. At another time I propose solving this question, and it would be well to reserve until then any hypothesis as to the real condition of a closed circuit contiguous to another carrying a voltaic current. It has always, however, appeared to me that the explanation of dynamic induction given by Prof. W. A. Norton (in this Jour., Jan., 1866,) in his paper on "Molecular Physics" affords a simpler and more consistent explanation of these phenomena than any heretofore framed.

Faraday (Exp. Res. 20 and 33) has also attacked the problem discussed in this paper. He introduced a small voltaic arrangement in the circuit of the secondary wire so as to produce a deflection of 30° or 40° in the galvanometer needles, and then a powerful battery was connected with the primary wire. He found, that after the deflection produced by the induced current had subsided, the needle resumed its former position and such he found was the case whichever way the contacts were made. For the following reasons I do not consider these experiments sufficiently refined to have solved so delicate a problem. First, from many experiments, which I have made, I have shown that no voltaic combination, however constant in the usual acceptation, can be formed so as to hold a galvanometer-needle even approximately in one position for only a minute, when it is examined by the method of reflection. Secondly, a needle already deflected 30° or 40° has lost its delicacy in showing any minute increase or diminution in the intensity of the current; thirdly, the greatest objection to this method is this very feeble induced current that can be sent through the great resistance of the battery in the circuit of the secondary wire; finally, the manner of reading the galvanometer indications is entirely too gross.

Faraday also (Exp. Res. 3186) approximately showed that when a magnet is quickly introduced into a wire loop or quickly withdrawn from the same that the currents induced in the latter, as measured by an ordinary galvanometer, are of the same intensity; but a deflection on such an instrument cannot be read closer than 15′, while in my experiments I have shown with more refined apparatus that magneto-electric waves can be evolved not differing more than 20″ in the deflections which they produce.

Though ignorance of science excuses one no more than ignorance of the law, yet I may remark that this apparatus was devised and the results obtained before I was aware of Faraday's work in the same direction.

Those who would use this means of obtaining magneto-electric waves of equal intensity must guard against changes of temperature; for both the intensity of the inducing magnet and of the galvanometer needles vary with the temperature, while the resistance of the wire of the spiral and of the galvanometer rises and falls with the same. Indeed if a method could be devised of keeping the wires and the galvanometer needles at a constant temperature while we altered that of the inducing magnet a refined method would present itself for the determination of the variation of the force of magnets with the temperature. Probably the effect of the heat upon the wire circuit could be tabulated and eliminated from the results of such experiments, thus leaving a residual which will express the effect of temperature on the magnet. Or, a differential apparatus might be devised, consisting of two magnets with two wire circuits passing through a differential galvanometer. Having brought the induced currents of the two magnets to equal actions by an interposed resistance, we could then, by altering the temperature of one of the magnets, ascertain its effect with great precision; and it could be expressed in the length of resistance required again to balance the disturbed equality of the magnets.

November 7, 1870.

ART. V.—*Abstract of the Programme for the Observation of Stars to the Ninth Magnitude, undertaken by the German Astronomical Society.*[*]

THE Astronomical Society undertakes the construction of a complete catalogue for the northern heavens of the stars of the first nine magnitudes, upon the basis of the Bonn Durchmusterung. The region to be observed lies between −2° and +80° of declination. The region around the pole is not included, as the labors of Carrington, the Kasan and the Hamburg observatories render a repetition of this work superfluous on the part of the Society. The work will be distributed as follows: Kasan 80° to 75°; Dorpat 75° to 70°; Christiania 70° to 65°; Helsingfors 65° to 55°; Cambridge, U. S., 55° to 50°; Bonn 50° to 40°; Chicago 40° to 35°; Leipzig 35° to 30°; Cambridge, Eng., 30° to 25°; Berlin 25° to 15°; Leipzig 15° to 10°; Mannheim 10° to 4°; Neuchâtel 4° to 1°; Palermo + 1° to −2°.

The limits of these zones refer to the equinox of 1855·0, which is that of the Durchmusterung. For purposes of comparison, the limits above given will be exceeded 5′ to 10′, and in very northerly regions even more.

In particular the stars to be observed are as follows: All stars of the D. M. within the prescribed limits having a magnitude of 9·0 or brighter; all stars fainter, which also occur in the Histoire Celeste (marked in the D. M., L), or in the Königsberg zones (marked K), or in the Bonn zones (marked A); a part of these latter, which have been recently determined at Bonn, (marked B). A comparison of the older collections of observations is consequently necessary for completeness.

Every star will be observed twice. Whenever necessary to discover disagreements, a third observation should be made. The observations will be differential in their character, and will depend upon a catalogue of 539 zero stars, to be determined at Pulkova.

To facilitate reduction as well as observation, it is recommended to the observers to divide the zones into subzones. It is deemed inexpedient to observe zones of a length of more than one hour and a half, both on account of the physical fatigue and also the too wide separation of the fixed points of reference. Two zones of one and a half hours each are preferable to a single zone of three hours.

The clock error and pole point will be determined altogether by means of stars from the Pulkova catalogue, mentioned above. At least two zero stars must immediately precede and follow each zone. Whenever desirable or necessary, however, one or more may be observed during the progress of the zone. In the selection of zero stars the peculiarities of the instrument must govern. In general the mean of their right ascensions should fall nearly on the mean of the zone. Where this cannot be attained, the observer must decide whether he can rely more upon a uniform clock rate (for the determination of right ascensions), than upon an unchanged position of the instrument in reference to the meridian. With very northerly stars the selection should be made more with regard to the declinations of the zero stars, as an error in the clock rate has less influence here. The mean daily clock rate must not be used in the reductions, but the rate resulting from the mutual comparison of the zero stars for the zone.

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[*] **Prepared for this Journal by A. N. SKINNER, of the Naval Observatory, Washington.**

The individual observer must judge whether a single microscope will give the requisite security in declination. Whenever the stars to be determined are observed on fewer microscopes than the zero stars, a thorough investigation of the reduction between the different systems of microscopes must be made throughout each zone. Where this reduction shows large changes, the use of all four microscopes is advised, and also the introduction of zero stars in the progress of the zone. Changes in the equatorial point may be determined also by horizontal collimators.

Where two share in the work, so that one reads the microscopes, and especially where only one microscope is read, the influence of the warmth of the observer's body must be carefully investigated and allowed for. (Consult Bonn Beob., II, p. viii).

In the observation of double stars the position of the mean is to be obtained. It is therefore advisable to extract from the Positiones Mediæ the double stars occurring in a zone. Should a star designated there as "simplex" appear double, in case of nearly equal brightness, the mean should be observed as well as the brighter one.

An ephemeris of variable stars will be published annually in the Vierteljahrschrift, to furnish information in regard to the most favorable times of observing them on the meridian.

There are many stars of the 9·0^m in the D. M. which are fainter, and it is much oftener so with those marked A. The observer is enjoined to spare no pains in observing these stars, and should the observation not succeed in the course of the zone, note should be made so that it may be attempted under more favorable circumstances. Where variability may be suspected because a star is invisible or excessively faint, it is advisable to immediately inform the committee or those astronomers engaged on variable stars, that these stars may be carefully attended to. A notice to the Bonn observatory would render it possible to scrutinize the original papers for any error.

Unless special circumstances prevent, the magnitude is to be carefully estimated at the observation of every star. It is desirable that the participants conform their scale of magnitudes to that of the D. M., unless some other scale is already in use; in that case its relation to the D. M. scale must be determined. (Consult Bonn Beob., III, p. xviii, ff.) To guard against a difference between observations of bright and faint stars, observers are recommended to observe variable stars in different stages of their brightness.

The choice of wire intervals both vertical and horizontal requires mature deliberation. The former must be arranged according to the declination; rather wide for equatorial zones, and rather narrow for northern zones. For eye and ear observing, wire intervals of 10^s to 12^s are recommended. Equidistant wires and in zones near the equator intervals of a whole number of seconds are to be avoided. With the chronographic method intervals of $2^s\cdot5$ to 3^s will suffice. The choice of narrower intervals cannot be recommended. The horizontal wires should not be too close, because the fainter stars cannot be seen distinctly through them. A definite precept cannot be given, as the magnifying power employed is closely connected with the question. The observer will do well to ascertain what distance suits him best. Bessel used at first a power of 66 times and afterwards one of 107 times; a third of 119 times, which was perhaps more proper, was not employed on account of its small field of view, a difficulty not to be encountered in the present work, as each star can be directly set upon. The distance of the horizontal wires was 8″, which is probably rather narrow. The Bonn northern zones were observed with a power of 108 times, those published in vol. vi with one of 150 times. The horizontal wire interval at Bonn is 14″, which is perhaps too wide; 10″ to 12″ may perhaps be more advantageous.

The final catalogue will be reduced to the equinox of 1875·0. It is earnestly recommended to make the reduction of the observations as soon as possible, so as not to be pressed at a later period by the work. Of course a definitive reduction is possible only when the accurate determinations of the zero stars are completed at Pulkova, which will take several years. Meanwhile the provisional places given at present will be so nearly correct that only small corrections will need to be introduced. This reduction will afford an opportunity of judging what security of position is arrived at and where perhaps a third observation is to be added. It will, it is hoped, appear from all the observations that the mean difference between two observations of the same star will not exceed $0^s\cdot1$ in R. A. (for northerly stars proportionally more), and 1″·2 in declination. This indeed is completely sufficient. It would follow from this that the probable error of a mean of two observations is 0^s·04 and 0″·05. But with the above mentioned mean differences among 22 chances the differences 0^s·25 and 3″ would occur once, and among 142 chances those of 0^s·34 and 4″·1 once. Accordingly it would be advisable perhaps as often as differences occur which exceed 0^s·3 and 3″·5 to make a third observation for verification.

The observer will do well to inform himself completely on the subject of the introduction of the D. M., found in Bonn Beob., III. It is there noticed that sometimes two very close faint stars by their united light have given cause to the introduction of a 9^m star which does not exist; such are to be observed if bright enough. If a 9^m star should be found which is not in the D M., and these cases are very rare, it is to be observed and the fact carefully noted, to be published in the final catalogue.

To secure the internal connection and completion of the whole, the participants are urgently requested to transmit, before July of each year, annual reports on the work of the year to the President, or one of the Secretaries, of the Society.

ART. VI.—*On Gahnite from Mine Hill, Franklin Furnace, New Jersey;* by GEO. J. BRUSH.

THE rare species Gahnite has been again found at a new locality in a cross-cut made by the New Jersey Zinc Co. from the valley of the Wallkill river to an opening on the south end of Mine Hill. I collected specimens at this locality in the summer of 1869, and by blowpipe examination at that time determined the mineral to be a zinc spinel.

The mineral differs in its crystalline characters from the specimens of other localities in the frequent occurrence of the cubic plane; in fact the cubic planes are often the largest, so that the crystals are cubes with truncated dodecahedral edges and only small octahedral planes. There are also minute planes of the trapezohedron 2-2, truncating the edges of the dodecahedron; also others of the trigonal-trisoctahedron 3. Besides these there are sometimes two planes between the cubic and the octahedral, which appear, from examination and approximate measurements by Prof. Dana, to belong to the forms 4-4 and 8-8. Their surfaces are rounded, and feeble in luster, and generally they are blended in a single curved plane, consequently the measurements are not entirely satisfactory. The inclinations on a cubic plane, obtained by Prof. Dana, are for 4-4, 160° 30′, for 8-8, 170° 30′.

The crystals vary in diameter from an eighth of an inch to over an inch and a half; generally, however, they are less than half an inch. The color of the crystals is blackish-green; in thin fragments, olive-green. Hardness = 7·5. Specific gravity =4·89—4·91.

Before the blowpipe the mineral is infusible. With the fluxes reacts for iron and manganese; and with soda on charcoal gives a zinc coating.

The analysis in the wet way was made by Mr. Joseph S. Adam of this laboratory. The mineral was decomposed by fusion with bisulphate of potash. The silica was separated in the usual manner, and the iron and alumina thrown down as basic acetates, and this precipitate was examined to insure purity. The iron was determined by titration with permanganate of potash. From the acetic solution the manganese was separated by bromine, and the zinc was thrown down from the filtrate by sulphid of ammonium. The small amount of magnesia was determined as pyrophosphate, care having been first taken to separate the minute traces of it which were found precipitated with the alumina.

Two analyses by J. S. Adam gave:—

	I.	II.	Mean.		
Alumina,	49·86	49·70	49·78	23·20	25·77
Ferric oxyd,	8·83	8·33	8·58	2·57	
Zinc oxyd,	39·39	39·84	39·62	7.82	8·12
Manganous oxyd,	1·20	1·07	1·13	·25	
Magnesia,	0·12	0·14	0·13	·05	
Silica,	0·71	0·42	·57		
	100·11	99·50	99·81		

This gives the relation of the oxygen of $\dot{\mathrm{R}}$ and $\bar{\mathrm{R}}$ as 8·12 : 25·77, or 1 : 3·17, which would indicate that a small portion of the iron was present as protoxyd. We have but to assume 1·56 per cent of the $\bar{\mathrm{F}}\mathrm{e}$ in the analysis to have existed as $\dot{\mathrm{F}}\mathrm{e}$ in the mineral to reduce the ratio to exactly 1 : 3.

This variety of gahnite shows a larger percentage of zinc than any heretofore analyzed, and is unique in its cubic habit. It is associated with black mica, apatite, calcite and a brownish variety of chrysolite. A partial analysis of this chrysolite by W. G. Mixter shows it to be a unisilicate of iron, manganese, magnesia and zinc, probably related to, and possible identical with, the zinciferous chrysolite described by Prof. W. T. Rœpper, in this Journal, II, 1, 35. A tin-white metallic mineral imbedded in some of the gahnite crystals proved to have the pyrognostic characters of leucopyrite.

Sheffield Laboratory of Yale College, Nov. 1870.

ART. VII.—*Meteors of November* 13*th*–14*th*, 1870.

1. *At New Haven.*—On the morning of the 13th of November, 1870, Mr. Charles S. Hastings and Mr. W. B. Roberts, of the Sheffield Scientific School, and Mr. A. A. Murch, of the Academical department of Yale College, watched for meteors upon the tower of Graduates' Hall, in New Haven, from half-past twelve to half-past three A. M. The sky was clear, or nearly so. The following is the result of the count:—

From $12^h\ 30^m$	to $1^h\ 0^m$	2 unconf.	1 conf. meteors.
1 0	1 30	4	2
1 30	2 0	6	1
2 0	2 30	7	1
2 30	3 3	3	1
3 0	3 30	3	0
	In 3 hours,	25 unconf.	6 conf. meteors.

The moon was about one sign in advance of the radiant, and evidently diminished very much the number of meteors that could be seen. Probably two-thirds or three-fourths of the whole number were thus made invisible.

On the next morning, that of the 14th, the writer, with Messrs. O. Harger, E. S. Dana, C. B. Dudley, J. McNaughton and R. P. Maynard, watched from shortly after eleven P. M. of the 13th, onward, with the following result:—

Time.	Unconf. met.	Conf. met.	No. of obs.	State of sky.
h. m. h. m.				
11 5 to 11 30	6	0	3½	Clear.
11 30 " 12 0	8	1	4	"
12 0 " 12 30	4	5	6	"
12 30 " 12 45	3	5	6	"
12 45 " 1 0	4	5	6	"
1 0 " 1 15	5	3	6	"
1 15 " 1 30	3	9	6	"
1 30 " 1 45	4	8	6	"
1 45 " 2 0	6	1	6	"
2 0 " 2 15	5	7	6	"
2 15 " 2 30	10	8	6	Light clouds.
2 30 " 2 45	5	6	6	Fleecy clouds over all the sky.
2 45 " 3 0	2	2	4	Cloudy.
3 0 " 3 15	3	7	6	Some clouds.
3 15 " 3 30	4	5	6	"
3 30 " 3 45	2	7	6	More cloudy.
Total in 4h 40m,	74 unconf.	79 conf.		

From $3^h\ 45^m$ onward the sky was so nearly overcast that regular counting was abandoned. Here and there open spaces in the clouds enabled us to be assured that up to six o'clock there was not a marked increase in the number of meteors. After half-past five, however, the clouds more nearly covered the sky.

As on the preceding morning, the moonlight was very bright. In the earlier part of the watch there was an aurora, with streamers reaching up half or two-thirds of the way to Polaris.

We called those meteors conformable which moved in paths which if produced backward would cut the curve of the sickle in Leo. But in the practical application of this criterion to tracks distant from the radiant it is probable that any which would strike within 10° of the center of the sickle were called conformable.

Of the apparently conformable meteors, some were undoubtedly accidentally so. The earth's motion being so nearly toward the radiant, a special tendency toward conformability in the sporadic meteors was the result. If we take 15 per cent of the 74 unconformable meteors away from the 79 conformable ones, and add it to the 74, it would be, I think, a tolerable correction for the *accidental* conformability. The numbers would then stand 85 unconformable meteors, and 68 November meteors, or *Leonids* as they have been called.

The only meteor seen by me near the sickle would correspond to a radiant one-third or one-fourth of the way from *gamma* to *epsilon* Leonis. It was moving at a large angle with the line joining those stars.

Many of the conformable meteors had the peculiar light and train which belong to the Leonids.

On the morning of the 15th the sky was overcast at New Haven. Between eleven and twelve o'clock P. M. of the 14th, however, there were a few breaks in the clouds. I think there could not have been any great number of meteors at that time, as I did not see a single one through the openings.

2. *At Brunswick, Me.*—The following is from a letter of Prof. Rockwood of Bowdoin College.

"I was abroad from $0^h 45^m$ till nearly 5^h A. M., Nov. 14th, and assisted by two members of the senior class of Bowdoin College, kept a watch and count as given below. The time is local time, as nearly as could be ascertained.

Time.	Conformable.	Unconformable.	Total.
$1^h 20^m$ to 2^h	4	4	8
$2^h 15^m$ " $2^h 45^m$	20	4	24
$2^h 58^m$ " $3^h 30^m$	25	4	29
$3^h 40^m$ " $4^h 10^m$	17	4	21
	66	16	82

"We saw 10 or 12 more, mostly conformable, at times when not engaged in the formal count. The sky was mostly clear, but sometimes partly obscured by a few light passing clouds.

"The number of meteors was not large but sufficient to prove the return of the November shower. Especially noticeable facts were—(1) the almost perfect conformity to the radiant of brighter meteors; (2) the uniformity in the number of the unconformable meteors.

"On the morning of Nov. 15th, 1870, it was cloudy and raining."

Upon the chart sent by Prof. Rockwood are six tracks of meteors observed by himself. The following are their apparent places of beginning and ending.

Time. Nov. 14th.	Beginning. R. A.	Beginning. Dec.	Ending. R. A.	Ending. Dec.
$2^h\ 49^m\ 30^s$	142°	+40¼°	135°	+51°
3 25 10	134	+13½	126¾	+ 8
3 40 30	139	+30½	133½	+35½
3 42 30	145	+20¼	141¾	+18¼
4 4 20	141½	0	136¾	−10½
4 9 30	150⅓	− 2¼	150½	−14½

The fourth of these paths was close to the radiant and would, if carried back, cut the line joining γ and ϵ Leonis *three-sevenths* of the way from *gamma*.

3. *At Burlington, New Jersey*, November 14, 1870.—Mr. B. V. Marsh observed meteors as follows: from $0^h\ 30^m$ A. M. to $0^h\ 45^m$ A. M., looking south from a window, 3 conformable. In the open air, attention directed principally toward the south, sky *perfectly* clear:

	A. M.		A. M.	Conformable.	Non-conform.	Total.
From	$1^h\ 30^m$	to	$2^h\ 0^m$	4	1	5
	2 0	"	2 30	3	0	3
	2 30	"	3 0	4	1	5
				11	2	13

Towards 3 o'clock clouds began to interfere materially, and at daylight the whole sky was covered. About half the number were equal to stars of 1st magnitude and several had trains, but there was no one that was worthy of special remark.

Mr. John G. Gummere from 1½ to 3 o'clock, saw 9 conformable and 2 non-conformable; total 11.

Prof. Kirkwood reports a cloudy sky at Burlington, Ind.

Probably Prof. Rockwood and Mr. Marsh had a less sharply marked criterion of conformability than that employed by us in New Haven. As the result of all our numbers, we may say that the number of Leonids visible on the morning of the 14th of November, was probably about equal to, perhaps exceeding, that of the sporadic meteors. In view of the disturbing effect of moonlight this comparison is more valuable than any comparison with the absolute numbers counted in clear nights.

H. A. N.

ART. VIII.—*On some phenomena of Binocular Vision;* by JOSEPH LECONTE, Prof. Geol. and Nat. Hist., Univ. of California.*

IV. *The mode of representing the position of double images.*

IT is well known that if two objects, as a finger of each hand, be placed one beyond the other in the median line of sight, when the eyes are fixed upon the nearer object the farther object is seen double, the images being *homonymous*, i. e. on the same side as the eyes to which they belong: and when the eyes are fixed upon the farther object the nearer object is seen doubled, the images being in this case *heteronymous*, i. e. opposite the eyes to which they belong. These familiar facts are usually represented graphically as follows: Let R and L, figs. 1 and 2, represent the right and left eye, and A and B the two objects. Now when the eyes are directed upon A, fig. 1, then the light from B will impress the *temporal* halves of both retinæ and B will be seen by the right eye at *b* and by the left eye at *b'* (heteronymous); but if the eyes be directed upon B fig. 2, A will impress the nasal sides of the two retinæ, and be seen as homonymous images at *a* and *a'*. (In all cases in this paper objects seen single are represented by capitals, right eye images by plain italics, and left eye images by dashed italics). It will be observed that in both cases the doubled images are referred to a plane passing through the point of sight at right angles to the visual plane. For convenience I will call this the *plane of sight.* Now every one who has ever tried the experiment knows that the double images are not thus referred in natural vision, but on the contrary are seen at their real distance, though not in their real position. The figures therefore though they truly represent the parallactic position of the double images do not represent truly their apparent distance. If on the other hand we attempt in our figures to refer the images to their proper distances, observing the law of direction, then they unite and form one; which is equally incorrect. It is evident therefore that these figures cannot represent truly the visual results.

The falseness of this mode of representation becomes much more conspicuous, if instead of two points or small objects, we substitute a line or rod. In this case the absurdity of projecting the images on the plane of sight is so evident that it is never attempted. The universal mode of representing the visual result of a rod placed in the median line of sight is shown in the accompanying figures. Fig. 3 represents the actual position of the rod AB in the median line of sight, fig. 4, the visual result when the eyes are directed upon A, and fig. 5 the visual result when the eyes are directed upon B. Now it will be observed that in both these figures the image of each eye is coincident with the visual line of the opposite eye, and therefore makes an angle with its own visual line equal to the visual angle. But this is not true. Fig. 3 shows that it ought to make but half that angle. If these figures therefore represent truly the position of the images, as indeed they do, then they do not represent truly the visual or apparent positions of the visual lines. The truth is, in natural vision the visual lines are shifted as well as the images of all objects not situated at the point of sight, and to the same degree, so that their positions relative to the visual line are perfectly maintained in the visual result.

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* For the preceding articles on this subject, see II, xlviii, 68, 153.

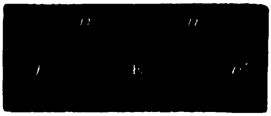
Figures constructed on the usual plan give correctly the position and distance of objects seen single, but fail to represent truly the place of double images. They are well adapted to express binocular combinations of similar objects or similar figures on the plane of sight, as in my previous experiments; and to some extent also in the stereoscope, but are unadapted to express the results of binocular vision of natural objects.

I propose therefore a new, and I am convinced, far truer mode of representing the results of binocular vision, applicable to all cases. I am satisfied that if this mode had always been used much confusion would have been avoided. Some preliminary explanation will be required to make the method clear.

If a *single* object, as a finger, be placed before the eyes in the median line of sight and the eyes be directed to a distant point, the object will be seen double, the heteronymous images being separated by a space exactly equal to the interocular space. Now, the *nose* is no exception to this law; the nose is always seen double and bounding the *common field* of view on either side. Again if *two similar* objects or figures be placed before the eyes in the plane of sight and separated by a space equal to the interocular distance, and the eyes be directed as before to a distant point, both objects will be doubled, but two of the doubled images, viz: the right eye image of the right object and the left eye image of the left object, will combine to form a *single binocular image* in the middle, while the right eye image of the left object will be seen to the left and the left eye image of the right object will be seen to the right. Thus there will be three images seen; the middle one binocular, the right one belonging to the left eye alone and the left one belonging to the right eye alone. Now, *the eyes themselves are no exception to this law.* In binocular vision the eyes themselves seem to double; *two of them combining to form a binocular eye in the middle which looks out between the two noses, while the other two are on either side beyond* the noses. Each eye seems *to itself* to *occupy the central position* while it sees (or would see if the nose was not in the way) its fellow on the other side of the nose. In other words, in binocular vision when the eyes are fixed upon a distant object the whole field of view, including the parts of the face, is shifted by the right eye one half the interocular space to the left, and by the left eye the same distance to the right, without altering the relative position of parts. By this shifting it is evident that the two eyes with their visual lines are brought in perfect coincidence, so that *identical points* in the two eyes are perfectly united.

The outline of the field of view varies somewhat with the prominence of the nose, brows and cheek bones, but its general form is much the same in all persons. I give in the accompanying figure (fig. 6) a rude outline of the field of view in my own case, *n n r r* being the field of the right eye, and *n′n′ ll* the field of the left eye, and the irregular space *nn n′n′* being the common field of binocular vision bounded by the outline of the nose *nn* as seen by the right eye, and *n′n′* as seen by the left eye. The circle E represents the position of the combined eyes in the center of the common field, *l* and *r′* the position of the two eyes as seen each by the other or rather as they *seem* each to the other. A vertical projection is shown in fig. 7. E being the combined eyes, *n* and *n′* the nose as seen by the right and left eyes respectively on either side of the common field, and *l r′* each eye as seen by the other. It will be observed that I have represented the eye on the extreme *right* by *r′* instead of *r*, and on the extreme *left* by *l* instead of *l′*. The reason is that these, like the two noses, are only heteronymous *images* seen by the two eyes respectively from their central position. As an *organ* of vision the two eyes occupy the central position only, but as an *object* each from this central position sees its fellow on the other side of the nose right and left. This vertical projection I shall use in all my diagrams representing double images. By its use, however, we may represent equally well the position of objects or images seen *single* at the point of sight. By this method the visual results of even the most complicated figures, not only may be represented truly and with ease, but may be *worked out* a priori with the utmost certainty. The great importance of this a priori help will be appreciated by all who have made experiments in binocular vision, and who therefore know how easy it is to overlook, or rather how difficult it is often to perceive, many of our visual impressions.

7.



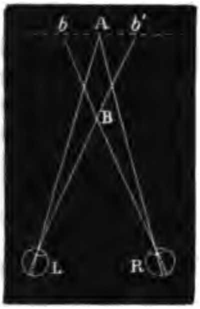
As we have already stated, while we gaze at a distant horizon any object in the median line *whatever be its distance* is seen double, the space between the images being exactly equal to the interocular space. Evidently then the median line of sight itself is doubled and becomes two lines which, resting upon the nose on each side of the common field of view, run out parallel to each other. *Between these two lines* the combined eyes look out along the *combined visual lines*, at the distant object. If the position of the median line of sight be occupied by a *real* line or rod we shall *see* two parallel lines or rods; if it be occupied by a *plane* as in the stereoscope, we shall see two parallel planes bounding the view on either side, between which we look.

Suppose now we take a slender rod AB *n* (fig. 8) like a straight wire, and placing one end on the root of the nose and the finger on the farther end, so that it occupies the position of the median line of sight, we look at a distant horizon. As already stated we shall see two parallel rods between which we look at the distant point, (fig. 9). If now we look at a nearer point the rods will converge, carrying all objects in the fields of view with them, and meet at the point of sight. If for example we look at the finger A, the rods will form a triangle of which the finger is the point and the distance between the two noses the base (fig. 10); if we look at a still nearer point B, the rods, still turning upon the noses as a fixed point, will cross each other at the point of sight, (fig. 11). At the same time the two eyes with their visual lines combine to form a median eye and a *true median line of sight* (the dotted line in the figures), passing through the point of sight and beyond to infinite distance, and this line might well be called by this name if the name had not been already appropriated for another line.

It will be observed that in the above paragraph I have used very much the same language as other writers on this subject, and used a similar mode of representation; only that I have substituted the eyes in the place of the nose and put noses in the position of the eyes. I have made median lines cross each other at the point of sight instead of visual lines, and visual lines combine in the middle as a true visual median line. In other words, I have used the true language of binocular *vision.*—I have expressed what we *see* rather than what we *know*, the language of simple appearance rather than that mixture of appearance and reality which form the usual language of writers on this subject.

In all the experiments which follow it will be necessary to get the interocular distance with accuracy. This may be very conveniently done by taking an ordinary pair of dividers, holding it up at arms length against the sky or a cloud, and while gazing steadily at the sky or cloud, opening the points until the double images of the points shall two of them coincide perfectly, thus: The distance between the points *b c* (equal to *a a'*) is the interocular distance.

1.



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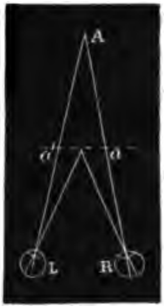

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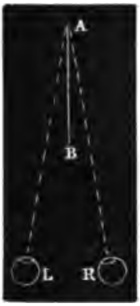

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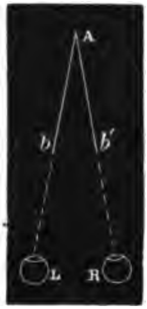

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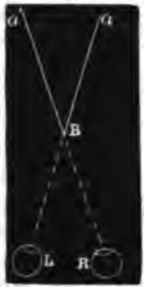

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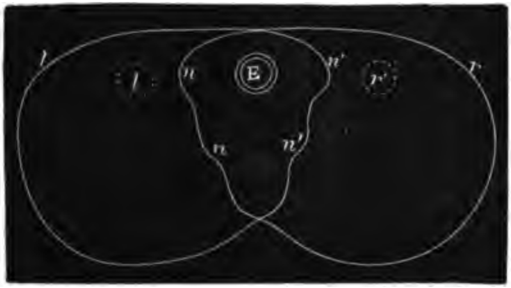

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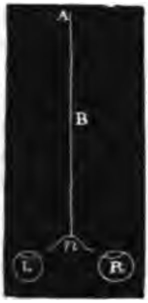

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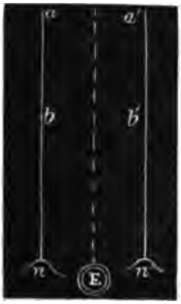

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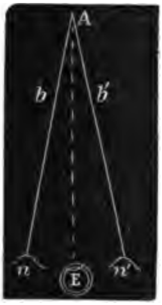

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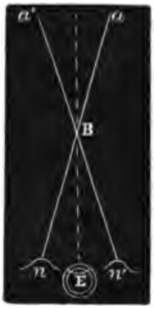

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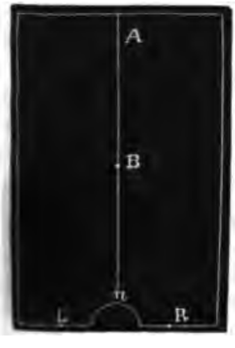

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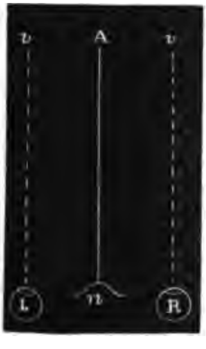

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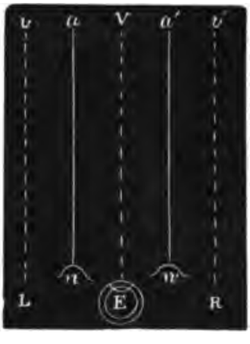


I will now give a few very simple experiments and the visual results, represented in the manner already indicated. Let a smooth white plane about twenty inches long and of any convenient width, be prepared by pasting white paper on a smooth flat board, (fig. 12). Mark two points R and S with a space between them exactly equal to the interocular space. In the middle between the two points notch the end of the board so as to fit over the bridge of the nose. From the notch *n* draw the line *n*A in the position of the median line of sight when the notch is fitted on the nose, and on this line place pins at A and B. If now, the plane be fitted on the nose and held in a horizontal position a little *below* the visual plane, so that both the pins and the line can be distinctly seen, and the eyes be directed upon a distant object; then, as already stated the median line will be seen as two parallel lines separated by a space equal to the interocular space. If in addition to the median line the position of the visual lines be represented by dotted lines, then fig. 13 will represent the *actual* relation of parts, and fig. 14 the *visual* result. It will be observed by comparing the visual result with the drawing, that the parts of the face, the whole plane and all the objects and lines on the plane are shifted by the right eye one half the interocular distance to the left, and by the left eye the same distance to the right; the two visual lines of the drawing are combined in the result to form a true median binocular visual line EV, while the median line of the drawing is doubled, forming heteronymous images, which in the result occupy the position of the visual lines of the drawing. Besides these three lines, there are seen two other dotted lines *lv* and *r'v'*. These are not visual lines proper, i. e. lines along which vision takes place, but they are the visible representatives of the visual lines of each eye seen *as objects* by the other eye.

Next, having removed the dotted lines in the previous experiment, let the eyes be directed upon the pin A, and dotted lines be again drawn in the direction of the visual lines as in fig. 15. The visual result is shown in fig. 16. By comparing this visual result with the actual drawing it will be seen that the whole triangle L A R, is turned upon A as a fixed point a half interocular distance to the left by the right eye, and to the right by the left eye.

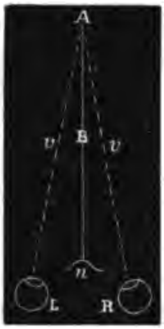
Next, having again erased the dotted lines of the previous experiment, and substituted dotted lines crossing at B as in fig 17; let the plane be again adjusted to the nose and the eyes directed upon the pin B. The visual result is shown in fig. 18. In this visual result the whole drawing (fig. 17) is apparently rotated about the point of sight B in opposite directions by the two eyes, through a distance represented by the angle *n*BR or *n*BL = half the visual angle. As objects on the nearer and the farther side of the point B must move in opposite directions, the double images beyond B must be homonymous. In this experiment (as also in a less degree in the last), since the eyes are converged, the distance between the points L and R *on the plane*, must be a little less than the interocular distance.

In both the above cases the visual result is the drawing rotated about the point of sight in opposite directions through one-half the visual angle; and for convenience I have spoken of the eyes as accomplishing this rotation. But this is not strictly true. The fields of view of both eyes are *habitually* and *normally* shifted one-half interocular space right and left heteronymously, when the eye is in a *passive* state. Under these conditions the visual results of figs. 15 and 17 would be figs. 19 and 20. But in converging the eyes upon A or upon B, the median lines *n b a*, *n'b'a'* turning upon *n* and *n'* as fixed points approach each other, meet and cross at the point of sight so as to form the result already given in figs. 16 and 18.

Lastly—if without using the plane, three objects A, B and C, be placed in the median line of sight, and the eyes be fixed upon the middle one B (fig. 21), then by the *usual* mode of representation the position of the double images of A and C will be *a'a*, *c c'*; the lines here representing of course not visible lines but only lines of direction. But if using the plane we draw a *visible* line in the direction of the median line, and upon it place three pins at A, B and C, (fig. 22), and connect these points with R and L, also by visible lines, and then direct the eyes upon B, the falseness of the former mode of representation becomes at once evident. The visual result of this experiment is shown in fig. 23. Every line of this somewhat complex figure can be distinctly seen. By comparing the two modes of representation (figs. 21 and 23), it will be seen that the parallactic position of the double images, or their position when referred to the plane of B, is the same (the dots represent these positions in fig. 23), but only the second mode (fig. 23) represents truly their apparent distance.

Thus there are two apparent movements of the visual fields accomplished by the eye (or the mind) in binocular vision: 1st, in a *passive state*, a *shifting* of each field one-half interocular space to the opposite side, so as to bring the two visual lines together to form a *true median* visual line; this movement is involuntary and habitual: 2d, in *ocular convergence* a *rotation* of each field in a direction opposite to the motion of the eye, on a line passing through the eye normal to the visual plane; this takes place in every *voluntary* act of sight. In all other movements of the eyes, as when we look from side to side or upward or downward, *objects* seem *stationary*, and we are conscious of the movement of the visual lines over them; but when the optic axes move toward each other as in convergence,

15.



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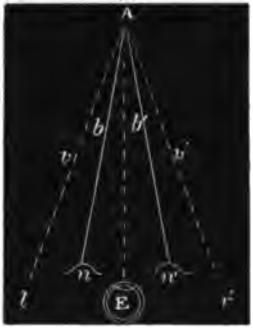

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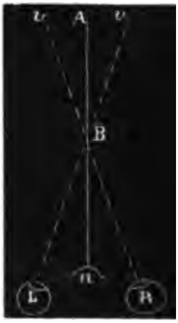

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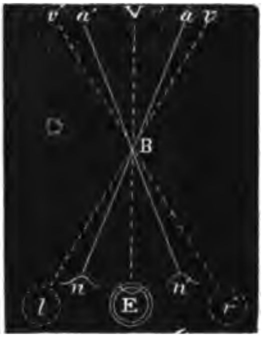

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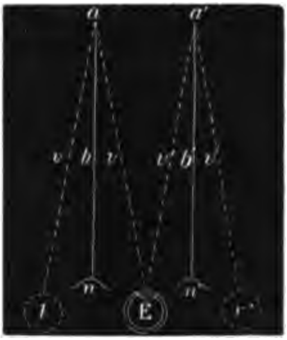

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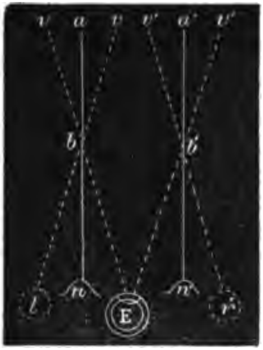

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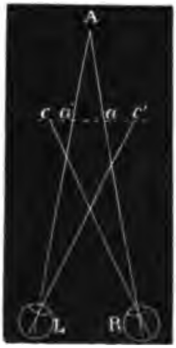

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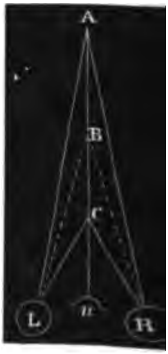

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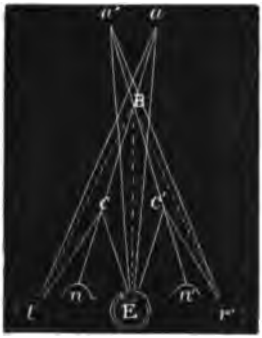

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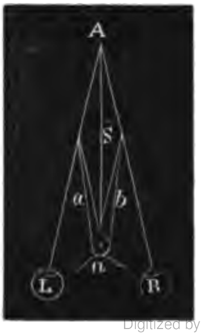
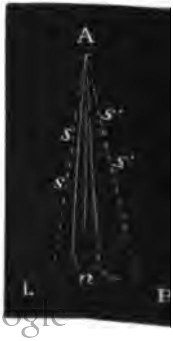


25.



all objects or images in the fields of view seem to move while the visual lines seem stationary. As the visual line of the right eye moves to the left all the images in its field seem to move to the right, and as the visual line of the left eye moves to the right all its images move to the left. Thus as the visual lines of the two eyes pass successively over objects in the external world right and left of the median line, the images of these objects move forward, and successively take position *directly in front*; so that under all circumstances the two visual lines combine to form a *median* visual line passing through the point of sight and onward to infinity. In case the images thus brought together are *similar*, as in my previous experiments, they combine, and are seen single at the point of sight; but otherwise they maintain their relative distances. This is especially true when we look at continuous lines on a plane parallel to the visual plane, as in the experiments detailed above. The fields rotate toward each other and images come together on the median visual line, but maintain their relative distances from the observer.

I might multiply experiments of this kind without number, but I wish now to show into what singular confusion some of the most careful observers have fallen by adopting the usual mode of representation. I will give first an experiment of Claparède which, according to him, is only a confirmation of what had been previously observed in the last century by Robert Smith, again in 1818 by Vieth, and again in 1838 by Wheatstone. It is therefore well fortified by great names. I translate:*—"Take a compass widely opened (fig. 24), apply its head to the root of the nose, holding the branches in the plane of vision. The screen S is so disposed that the left eye L sees only the branch *a*, and the right eye R only the branch *b*. If now we press the branches until the points are brought on the optic axes, (the point of sight being at A) as indicated in the figure (fig. 24); *we will perceive a closed compass* between the images *s s s′s′* of the screen (fig. 25), and this compass stretches itself even to the point of view A." Now I have repeatedly tried this experiment and I find the visual result entirely different. This result is shown by my mode of representation in fig. 26. It is *two half compasses united at the point and separated at the head, by the whole common field of view.* It cannot be otherwise, since we must see two noses bounding the common field of view on each side, and the head of the compass resting on the nose must be similarly doubled and the images similarly separated. As to *length*, the compass may be imagined of *any extent* short of the point of sight A. If the compass is placed *exactly* in the plane of vision, the experiment succeeds equally well without the screen, for in that case only the right branch can be seen by the right eye, (the left branch being covered by it), and the left branch by the left eye. If the compass be placed a little below the plane of vision, so that both branches may be seen by each eye, or better if it be laid on the plane before described as in fig. 27, then the visual result will be represented by fig. 28.

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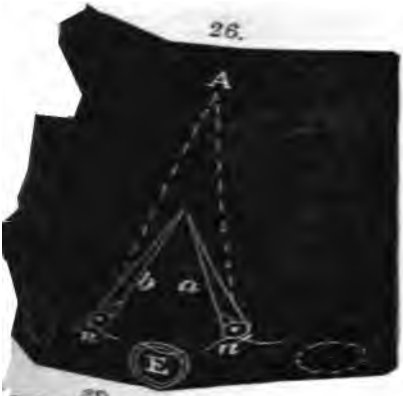
* Bib. Univ. Archives des Scien., II, Tome 3, p. 254.

The error in the interpretation of this very simple experiment, is due to the difficulty which most persons, even good observers, experience in separating what they *know* from what they *see*. In this experiment we *know* that the nose is in the middle between the eyes; we *know* also that the head of the compass is on the nose; and we *see* that the two points of the compass are together, therefore we *imagine that we see* a closed compass stretching from the nose to this point. But this is not only different from what we really see when our visual impressions are properly analysed, but is contrary to the first principles of binocular vision. The head of the compass impresses the extreme temporal limits of the retinæ of the two eyes, and must therefore not only be seen double, but *the double images are separated by the whole common field of view.* It seems almost incredible that images so widely separated should be imagined single.

Again: in Guy's Hospital reports is found an elaborate series of papers on the "Physiology of Vision," by Joseph Townes, extending through 8 vols., viz: 3d ser., viii and xv inclusive. Mr. Townes' experiments are performed with great care, many o them with the apparatus, and in the manner, already described. He has also *in most cases* truly described and truly drawn hi visual impressions, *as far as he has distinctly perceived them.* Bu on account of the faulty mode of representation he seems t have neglected one half of the visual impressions which h ought to have perceived. His papers also show misconceptio on some fundamental points in binocular vision which I canno now notice. I wish now only to compare his visual result with my own, and thus to show the superiority of my mode o representation. Among his many figures I will select onl two, as the principles involved are precisely the same in all.

In the accompanying figure (fig. 29) I reproduce his drawin fig. 1. Pl. I, only changing the lettering so as to bring it int accord with the previous figures of this paper. The visual result which he obtains when this drawing is viewed on the plan already described, the point of sight being at A, is given in fig 30. In this result V is the combined visual lines *v r* and *vl*, *b* is the median line B of the drawing, as seen by the right eye and *b'* the same line as seen by the left eye, but the right ey image of *v l* and the left eye image of *v r* are entirely overlooked

26.



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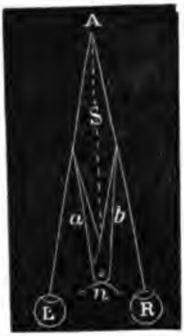

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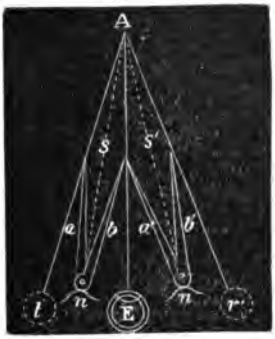

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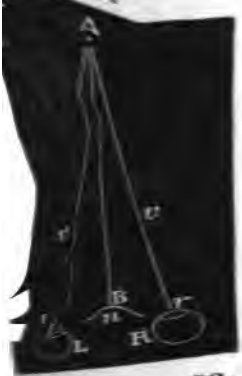

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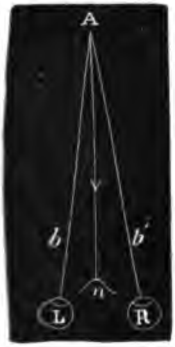

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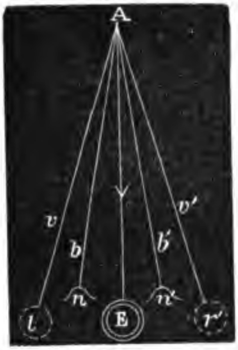

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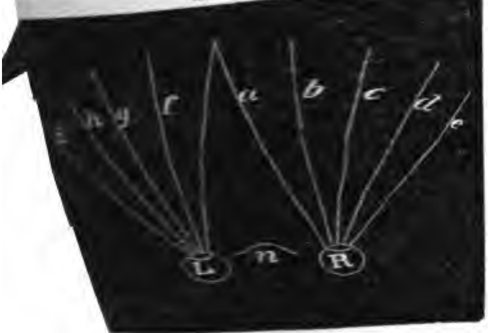

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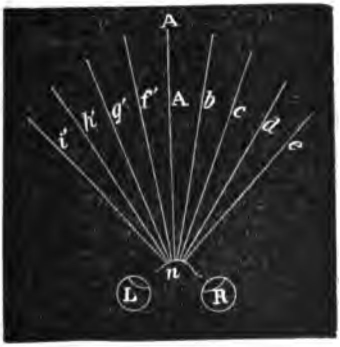
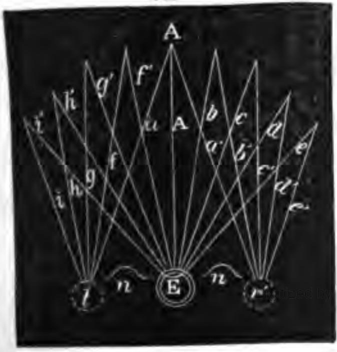


34.



The result which I obtain is given, represented by my method, in fig. 31.

In fig. 32, I reproduce one of his more complex drawings, viz: fig. 1 of his Pl. II, lettering of course as before. The visual result which he obtains by viewing this figure with the point of sight at A is given in fig. 33, where A n is the combined lines A R and A L of the drawing, $b\,c\,d\,e$. The corresponding lines of the drawing, as seen by the right eye alone, and $f'\,g'\,h'\,i'$ corresponding lines of the drawing as seen by the left eye alone. My result is given in fig. 34. By careful comparison of these two results, remembering that capitals represent combined images, small italics right-eye images, and dashed italics left-eye images, the nature of their differences will be readily understood. Mr. Townes in his result makes the right eye shift to the left *only the right portion*, and the left shift to the right *only the left portion*, of the drawing. My result shows the *whole drawing* shifted by the right eye to the left and the left eye to the right. Mr. Townes has neglected entirely the left eye images of $b\,c\,d\,e$, and the right eye images of $f\,g\,h\,i$. Every one of his visual results of figures drawn on the plane described, except a few in which he used a median septum, are faulty in the same way, and may be reconstructed on the same principle, with the utmost certainty, even before performing the experiment.

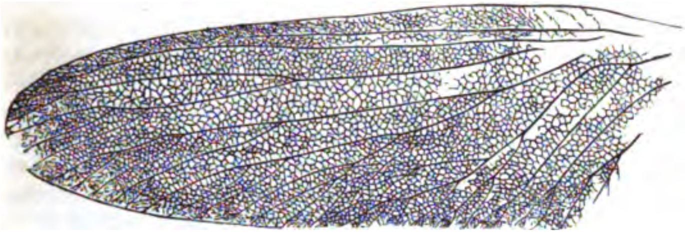
Oakland, Cal., Sept. 27, 1870.

Art. IX.—*Brief Contributions to Zoölogy from the Museum of Yale College.* No. IX.—*Notice of a Fossil Insect from the Carboniferous formation of Indiana;* by Sidney I. Smith.

Paolia vetusta, gen. et sp. nov.

The fossil insect wing, represented in the accompanying figure, was sent for examination and description, from the Museum of Hanover College, Indiana, by Prof. E. Thompson Nelson. It occurred in the "grit" quarry near Paoli, Orange county, Indiana, and was discovered by the workmen while sawing the stone into small pieces for whetstones. The fossil is remarkably perfect, nearly the entire wing being beautifully preserved, and of peculiar interest for showing the complete wing-skeleton of an insect so ancient as the coal period. It is apparently the anterior wing of the left side, and measures 2·54 in. in length and about ·85 in. in breadth, the posterior margin being slightly cut away by the saw.

Along the anterior border, the space between the second and third nervures is bent abruptly downward in the specimen, so as to be somewhat foreshortened as seen in the figure. This is probably a natural fold such as is found in many Neuropterous insects.



The neuration is remarkable for the number of slender branchlets which the nervures throw off toward the posterior border and the tip of the wing. The first, or marginal, nervure* is continuous to the tip of the wing. The second is simple and straight nearly to the extremity, where it throws off several very minute branchlets and itself impinges upon the margin, about three-fourths of an inch from the tip of the wing, as a very delicate nervure. The third divides a short distance from its origin; the anterior branch runs parallel to the second nervure, is separated from it nearly as far as the second is from the first, and is simple to near its extremity, where it is twice forked, the minute branchlets reaching the margin a little way from the tip of the wing; the lower branch is broken and wanting just at its origin; it forks about the middle of its course, the anterior of these secondary branches again subdividing like the anterior primary branch, while the posterior secondary branch divides about the middle of its course, the anterior of these tertiary branches again dividing near its base, and the anterior of the branchlets reaching the margin at the apex of the wing. The fourth nervure divides a third of the way from the base to the tip of the wing; both these branches fork or branch several times, so that there are twelve branchlets extending from them to the margin, and one from the posterior, or inner, side which is lost in the space between the fourth and fifth nervures and does not reach the margin. The fifth divides near the base of the wing; the inner branch runs an almost straight course to near the margin where it divides; the outer primary branch divides about the middle of its course, both its branches again dividing or branching several times, and the first branchlet on the outer side not reaching the margin. The basal portion of

Figure 1, is once and a half natural size lineally, and was drawn on wood from a photograph.

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* For convenience of comparison, I follow Heer's notation of the main nervures of the Neuropterous wing, as adopted by Mr. Scudder, regarding what are usually considered the primary branches of the median as distinct nervures, making six in all.

the sixth nervure is wanting in the specimen, but undoubtedly divides at its origin. The outer branch forks a short distance from the margin, and the outer of these branchlets, and probably the inner also, again fork very near the margin. The inner branch forks about the middle of its course, both these secondary branches forking once or twice.

All the interspaces are filled by a finely reticulated and very delicate net-work of minute nervures, but there are no straight cross-nervures. There is, however, a series of nervures running from the second nervure to the anterior margin, which are stronger than the general net-work, but still seem to be a part of it.

This wing differs so much in neuration from any family of recent insects, that it is difficult to point out any near affinity with living forms, although it shows some points of resemblance to several families of Neuroptera, and especially to the Ephemerids. To *Hemeristia* and *Miamia*, described and figured by Prof. Dana* and Mr. Scudder,† from the Carboniferous formation at Mazon creek in Illinois, it shows more resemblance, but still differs more from either of these genera, which are considered distinct families by Mr. Scudder, than they do from each other. From the forms described by Mr. Scudder in the third volume of the Geological Survey of Illinois, it is even more widely separated.

To the species described from the European Carboniferous, it seems to be still more closely allied. Prof. Hagen, to whom a tracing of the specimen was sent, is of the opinion that it will be found to belong to the same genus as the *Dictyoneura libelluloides* of Goldenberg.‡ Prof. Hagen, also, regards the remarkable *Eugereon Böckingi* Dohrn,§ which has attracted so much attention, as the same genus, and perhaps the same species, as *D. libelluloides.* In both *Dictyoneura* and *Eugereon*, as figured, the wings have considerable resemblance to the specimen from Indiana, but in neither of them are the nervures so numerously branched toward the posterior border of the wing, and in *Eugereon* the spaces between the three first nervures next the anterior border are connected by straight cross-nervures. There are also important differences in the branching of the main nervures. Regarding these differences as at least of generic value, I propose to institute a new genus for the species from Paoli, and call it *Paolia vetusta.*

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* This Journal, vol. xxxvii, pp. 34, 35, figs. 1, 2, 1864.

† This Journal, vol. xl, p. 268, 1865, and Memoirs Bost. Soc Nat. Hist., vol. i, p. 173, pl. 6, 1866.

‡ *Die fossilen* Insecten der Kohlenformation von Saarbrücken (aus den Palæontographicis von Dunker und Meyer, Band iv, 1854), pl. 1.

§ *Eugeron* Böckingi, eine neue Insectenform aus dem Todtliegenden (aus Palæontographica von Dunker, Band xiii, 1866, pl. 41.

ART. X.—*Earthquake of October 20th, in Northeastern America;*
by ALEX. C. TWINING.

NOTICES of the earthquake of October 20th last, collected from the newspapers and received from other sources, display an area of disturbance extending from New Brunswick in the East, to the State of Iowa in the West, and from the Lakes and the River St. Lawrence in the North, to Cincinnati and Richmond, Va., in the opposite direction. No doubt the actual area of disturbance was far more extended, especially in the East and North; for the manifestations were at least as strong in degree at the utmost bounds of our information in these last directions, as in those parts with which we are most immediately familiar. The same conclusion is confirmed by the circumstance that, even where the motions were most fully developed, they were not obvious to persons not favorably situated for receiving impressions from them. It is easy to believe that they escaped public attention over large regions where they took place sensibly, although but feebly.

At this place—New Haven, Connecticut—the movements, both in the precise time of their occurrence and in the attendant circumstances, were immediately and critically investigated by the writer, from the testimony of many intelligent citizens. Independently, and in their various situations and positions, the witnesses agreed in describing an oscillatory movement, to and fro, in the general direction of N.N.E. to S.S.W.,—not level but rocking. This last sensation is plainly indicative quite as much of a vertical displacement, combining irregularly and oppositely with the horizontal, as of any alternations of inclination in the earth's surface, after the manner of a wave, and a consequent vibratory condition of persons and objects. Still, that the latter did take place is a conclusion that seems to be made inevitable, by the invariable fact that the oscillations were by far the most perceptible in lofty situations,—for example, in the ascent progressively from the lower floors of edifices to the upper stories. In the latter, at least, objects were both felt and seen to be in motion; and suspended objects, as lamps and pictures, were set into vibration, with a range of three or four inches and, when free, in the direction already specified. There were two distinct shocks. In estimating the duration of these and of the interval between them, and also in estimating their component oscillations, these durations and intervals were in no case recorded from mere verbal statements, but means were employed to ascertain the informant's *mental* impressions and recollections, applying to them my own measurement, as to time.

These impressions and recollections would often give durations more than double, in some instances, of the like in other instances. Taking, however, the most trustworthy, and allowing to the others a weight proportioned to their value, under the circumstances, the first shock was found to have continued through about nine seconds, the second through about eleven seconds, and the interval about five,—making, altogether, twenty-six seconds. The time of each double vibration—that is both to and fro—was concluded to approximate to a second and one-third,—although, so far as mere numbers were concerned, the witnesses more generally approved not more than one second, or even less. The precise time of day will be referred to farther on. It is remarkable that motions which were not even noticed, ordinarily, by persons in basement stories or in the streets, should have produced in most of those who felt them nausea or dizziness or other affections, according to the temperament of the individual.

A careful comparison of the various newspaper paragraphs which have come to hand—nearly forty in number—makes it clear that the general phenomena were everywhere the same. Every where there were two shocks experienced of a few seconds each, and a brief interval. These are about as variously stated in duration by the newspapers as the same were stated by different observers at New Haven:—thus, at Troy 15 to 20 seconds in all, at Montpelier 30, at Cleveland 15 to 30, the prevalent authority being for the latter, at Boston 18 to 30, at Brunswick, Me., 30 to 40, at Cincinnati 30 and less, at Hartford 20 to 60, at Cornell University, Ithaca, three shocks of 15 seconds each—the *three* being too exceptional among the mass to be credited, and having but one other parallel, that is, Brooklyn. At Harvard College Observatory the duration of tremor was from 8 to 15 seconds by the estimate of different observers,—two shocks with a continuous tremor between, and the component oscillations 40 in a minute according to observer W. A. Rogers. At East Saginaw, Mich., the first shock is described as 10 seconds, then an equal interval, then a second shock of 10 seconds. A very few of the statements are so abnormal, one or two in their brevity (one or two seconds) and about as many in their length (two or three minutes), that no weight can be accorded to them. On the whole, the entire duration—26 seconds—at New Haven, is confirmed as having been about the duration in all other places observed—a uniformity probable in itself. In one instance the oscillations are spoken of as four or five in a second, and as being like the motions of a boat,—also in one other (at Keene) they are described as having been vertical.

Respecting the relative amount of disturbance at different places, the sensations experienced by individuals would be but a fallacious test, because so much influenced by temperament, as well as by situations and positions. Persons sitting, for example, were far more sensitive than persons standing. Again, while operatives in upper rooms often rushed down—as here at New Haven—in a panic, persons standing or walking in the immediate vicinity below, did not even perceive the phenomenon. The same remark applies to the reported swaying of walls and buildings ten inches to a foot, which is no doubt exaggerated in amount. But a vague conclusion may be derived from specific occurrences, such as the displacement of objects, the cracking of window panes or of ceilings, and the falling of chimneys, as well as from the degree of public notice which the event excited. All that, in the present instance, can be rationally deduced from such indications would seem to be that the amount of disturbance at New York, at Cleveland, at Milwaukee and Detroit was about the same as at New Haven; that it was greater at Boston, at Brunswick, at Montreal and at Quebec; that it was less at Cincinnati, at Chicago, and at Dubuque, and was but just distinctly perceptible at Richmond, Va. In other words, the movement was more remarkable in the East and North, and less in the West and particularly in the South. It is also believed that no like occurrence comparable in the aggregate with this one has been experienced in New England during the present century, nor since November 18, 1755—supposing the newspaper quotation, relative to that event, made by a Boston correspondent, from "a book published in 1786" to be correct and authentic.

It only remains to compare the times noted at the various places concerning which our information is sufficiently authentic. At this place there were two among the observers who separately noted the time by reference to standard time-pieces. By each the same time of beginning was given, within a few seconds;—that is, $11^h\ 19^m\ 46^s$. The average of three other observations by time-pieces whose errors could not be ascertained except on the day after, proved to be very nearly the same. The same conclusion was farther confirmed, with sufficient exactness, by the average of three clocks which had stopped, as observed upon their dials. Prof. C. Smallwood of Montreal Observ'y has obligingly furnished observations of local time in the Canadas which are entitled to confidence, viz., at Quebec, Montreal and Owen's Sound, and also at St. Johns, N. B. These will be found in their place in the table below. The time at Boston, taken by Mr. Farmer with care, is communicated by Prof. Newton, together with most of the newspaper notices herein referred to. That at Harvard College Observatory has been obligingly furnished to the writer by Assistant Arthur Searle, together with the other facts herein stated as observed at that locality. The time at Cleveland, Ohio, is the average of three clocks that were stopped, and is confirmed essentially by Col. Whittlesey, but without an actual reference of either to a standard time-keeper. From these combined the following table is composed; of which column 1 gives the place of observation; column 2, the latitude; column 3, the difference of local time from New Haven corresponding to the longitude; column 4, gives the respective local times corresponding to $11^h\ 19^m\ 46^s$—the beginning at New Haven; column 5, is an empirical scale of progress proportioned to the differences of longitude and the presumed differences of absolute time at St Johns and Chicago; column 6, gives the observed times of the earthquake; column 7 is comparative of the two preceding, and shows the presumed error of observation, whether too late or too early at each of the places respectively. It would obviously only obscure the discussion to take account in the table, of times which do not purport in the notices themselves to be near approximations, or which are adopted from the railroad time-pieces without supplying the proper correction, or which are found by comparison with the mass of observations to be grossly in error. To one or the other of these categories belong the notices from Brunswick and Portland, Me., Burlington, Vt., Warrensburg, Saratoga, Cooperstown, Cornell University, and Auburn, N. Y., Scranton and Titusville, Pa. The notice from Cincinnati, Ohio, is retained on account of the extreme position.

1.	2.	3.	4.	5.	6.	7.
Place of Observation.	**Lat. of place.**	**Time diff. from New Haven.**	**Simultaneous local Times.**	**Empirical Times.**	**Observed Times.**	**Diff. early or late.**
	° ′	m. s.	h. m. s.	h. m. s.	h. m.	m. s.
St. Johns, N. Bruns.	45 9	+27 34	11 47 20	11 45 5	11 45	0 5 early.
Bangor, Me.	44 48	+16 34	11 36 20	11 34 55	11 35	0 5 do.
Lewiston, Me.	44 5	+10 46	11 30 32	11 29 33	11 30	0 27 late.
Boston, Mass.	42 21	+ 7 28	11 27 14	11 26 30	11 25½—	1 1 early.
Harv. Coll. Obs'y.	42 23	+ 7 11	11 26 57	11 26 14	11 25⅘+	0 25 do.
Quebec, L. C.	46 49	+ 6 38	11 26 24	11 25 44	11 27	1 16 ate.
Providence, R. I.	41 50	+ 6 7	11 25 53	11 25 15	11 26	0 45 do.
Norwich, Conn.	41 33	+ 3 14	11 22 50	11 22 25	11 20	2 25 early.
Montpelier, Vt.	44 17	+ 1 18	11 21 4	11 20 48	11 24	3 12 late.
Hartford, Conn.	41 46	+ 0 59	11 20 45	11 20 30	11 20½+	0 4 do.
New Haven, Conn.	41 18	0 0	11 19 46	11 19 36	11 19¾+	0 10 do.
Montreal, L. C.	45 31	— 2 38	11 17 8	11 17 7	11 17	0 7 early.
Dudley Obs., N. Y.	42 40	— 3 20	11 16 26	11 16 31	11 15 —	1 16+do.
Hudson, N. Y.	42 14	— 3 22	11 16 24	11 16 29	11 14	2 29 do.
Schenectady, N. Y.	42 48	— 4 0	11 15 46	11 15 54	11 15	0 54 do.
New York.	40 43	— 4 20	11 15 26	11 15 35	11 15	0 35 do.
Warsaw, N. Y.	42 43	—20 58	10 58 48	11 0 13	11 0	0 13 do.
Toronto, U. C.	42 40	—25 44	10 54 2	10 55 48	10 55	0 48 do.
Owen Sound, U. C.	44 44	—32 2	10 47 44	10 49 58	10 52	2 2 late.
Cleveland, Ohio.	41 30	—35 10	10 44 36	10 47 5	10 44⅔	2 25 early.
Cincinnati, Ohio.	39 6	—46 6	10 33 40	10 37 8	10 30	7 38 do.
Chicago, Ill.	42 0	—58 38	10 21 8	10 25 23	10 25	0 23 do.

From all observed times of the *end*, if expressly so given, twenty-six seconds has been deducted for the *beginning*, as above. Wherever no mention is made of the period in the shock to which the observation applies, the times stated in the notices respectively have been inserted in the table without change, as being the presumed time of the beginning.

An inspection of this table discloses no considerable north-and-south movement. A nearly east-and-west progress is that which appears most consistent with the aggregate of times. Indeed it presents itself as the only one at all consistent with a uniform and regular progress. Nor is there discovered in the table any decisive indication of a change of direction as between the east and the west of the Alleghanies; but the various accounts, so far as they go, indicate the very reverse. Thus the direction of N.E and S.W., noted at Brunswick, was accurately N. 10° E. at Harvard Observatory, while it was N.N.E. at New Haven, and almost identically the latter also at Chicago. But at Cleveland and Detroit it is described as E. and W., and at Burlington, Vt., N. and S. One account from Boston makes it, incorrectly, N.W. and S.E., and another from Hartford the same at the latter place.

The best approximate result appears to be that the earthquake made progress from about E. 6° N. to about W. 6° S., *at the rate of one hundred and sixty miles a minute*, being six minutes and a half from St. Johns to Chicago; *while surprisingly, the ordinary direction of the subordinate undulation was about N. by E.* But there was not absolute regularity of rate in any single direction. The times at Cambridge, at Albany and at New Haven compared together, disclose appreciable deviations from the general *regimen* of the table; and the same is probably true with respect to the Cleveland observation. Unfortunately the latter was not checked by comparison with a standard time-piece,—neither, as is probable, was the Owen's Sound observation. That at Cincinnati does not purport to be more than a loose approximation.

It appears by observations of Prof. Hough at Dudley Observatory, obligingly furnished me by him, that the principal shock was observed at $11^h\ 15^m$, being a few seconds in duration, but that a tremor continued for at least a minute. No doubt there exist, at various localities not heard from, many observations recorded or distinctly remembered. It is desirable yet to have them communicated to this place, or to some one elsewhere, by whom they will be made available.

In fact while this article is in press, I am furnished through the favor of H. Paton, Esq., of the Montreal Telegraph Co. at Quebec, with the following important statements by Mr. Robert McCord, the operator who made inquiries immediately after the cessation of the earthquake at that office, and received replies from Montreal. His condensed statements are: "All perceptible motion was over here by the time I had finished telegraphing to Montreal—*do you feel earthquake.* It would take about eight seconds to telegraph the words used. The operator's immediate reply was—*no.* About fifteen seconds after, he said —*here it is.* The gentleman at Montreal afterward explained that, although he said *no*, he did experience a slight movement at the time, but was not aware that it was caused by an earthquake. He telegraphed—*here it is*—on the instant that the shock became sensibly evident. He cannot say how long the vibration lasted after that period, accurately, but is of opinion it continued for nine or ten seconds. The following further particulars be may of interest. The shock passed over this district from a northerly direction,—a rumbling sound accompanied the shock, resembling that produced by ponderous machinery,— noise and motion increased steadily for some seconds, and gradually passed away. Buildings were violently shaken. Our office being in the upper part of a high brick building, the trembling was powerfully felt—the clock in the office was stopped by it at 11:25, but am not certain if the time by it previous to the shock was correct. Some observers say the shock was first felt here a few seconds before 11:24, and lasted forty seconds —others state fifty or sixty seconds. I am of opinion it lasted sixty seconds. No two opinions agree as to the commencement and duration."

"At Bay St. Paul and Les Eboulements—places about ninety or one hundred miles northeast of Quebec—the ground opened in several places, and water was thrown up. Slight elevations of land in some places were produced. The country in the vicinity of St. Paul's Bay is of volcanic formation, and slight shocks are of frequent occurrence. A gentleman from that vicinity informs me that they had twenty or thirty slight shocks within the past two weeks. The shock on the 20th, here, did not appear to have an undulating, upheaving motion, but to partake of a tremulous nature."

"The operator at Richmond, a place ninety miles southwest of here, says the shock was just passing away there at the period when I made the inquiry of Montreal."

Mr. McCord does not refer to specific authority for the convulsive effects at Baie St. Paul and Les Eboulements, some 55 to 62 miles in a direct line from Quebec; but they are in general conformity to what has long been known to British geologists respecting the volcanic character of the region specified. They, in fact, recall and confirm the representations made at page 236, vol. xxx of this Journal, 1836, in a paper by Capt. R. H. Bonnycastle, R. En. In that region, very probably, lay the initial spot of the disturbance. The subject, in this view of it, merits a more extended investigation, and it is hoped that the statement here brought out will induce new communications relative to the facts.

The interpretation of Mr. McCord's interesting statements relative to the telegraphic communication, seems to be as follows: He occupied the last eight seconds of the motion at Quebec with a question put to Montreal. That question, together with the answer "no," I find by careful trial at the American Telegraph office. require not less than eighteen seconds for transmission and reception. Then there are estimated fifteen seconds of interval. Then there was the second reply of not less than eight seconds; then there were nine or ten seconds to the end of the vibrations. In other words, there transpired not less than forty-two seconds between the end of the message and of the tremors at Quebec, and the end of the same at Montreal, ninety-six miles distant in longitude, and one hundred and fifty-nine in a line N. 51° E., and which in the table above had been and still remains credited with the empirical interval of thirty-nine seconds,—showing a near accordance between these and the other facts, and 137 miles per minute of east-and-west progress.

Again, the Montreal "no" was given just as the tremors there began, and after—say six seconds after—the end of the shock at Quebec; that is to say, the beginning traversed from city to city in some six seconds more than the duration of the shock. Consequently the latter, in consistency with the above, must have continued about thirty-six seconds, in place of the twenty-six seconds ascertained at New Haven. Still again, the shock at Montreal began with the "no," which may have occupied four seconds. Then there were fifteen seconds of interval; then eight of reply; then nine to ten of estimated continuance; in all thirty-six or thirty-seven seconds for the duration of the shock. The principal movement at Montreal did not come till at least fifteen seconds after the beginning; and the testimony of the Richmond operator shows that the violence of the shock there had passed, while the tremors at Quebec were still in faint continuance. Finally, it will be observed that the time of occurrence stated by Mr. McCord and others—although not confirmed by his comparison with any standard time-piece—*tends* to represent the actual occurrence at Quebec to have been before the empirical time of column 5 in the table, instead of 1^{m} 16^{s} later, as shown in column 7.

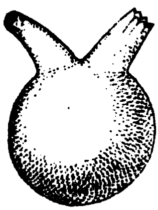
ART. XI.—*Brief Contributions to Zoölogy from the Museum of Yale College.* No. X.—*Descriptions of some imperfectly known and new Ascidians from New England;* by A. E. VERRILL.

Molgula Manhattensis Verrill. Figure 1.

Molgula Manhattensis **Dekay, Report on the Natural History of New York, Mollusca, p. 259, 1843; Binney, in Gould's Invertebrata of Massachusetts, 2nd ed., p. 25, 1870, (copied from Dekay).**

BODY somewhat oval, subglobular, or slightly cordate, usually somewhat compressed laterally; when crowded often slightly adhering together laterally and more or less deformed; usually adhering to eel-grass (*Zostera*) and various sea-weeds, or to the under side of stones, by the left side, or obliquely by the basal portion. The surface including the tubes is generally thickly covered with fragments of eel-grass, broken shells, particles of sand, and various kinds of debris so as to entirely conceal the surface and disguise the form; sometimes, however, in sandy regions the surface is nearly destitute of such covering. The integument is firm and thick, and when clean it is translucent and roughened throughout with minute, granule-like papillæ, which are larger and more crowded on the upper part and around the base of the tubes, where they often form small, rough, unequal verrucæ. The tubes originate on the upper side, a little apart, the distance between usually about equal to the diameter of the anal tube;* they are both rather long and diverge by curving outward from the base. The anal tube is smaller and somewhat longer than the branchial, usually about equal in length to half the diameter of the body, and tapers to the end, which is rounded and has a small square aperture, its sides, near the end and often below, are usually roughened by irregular, uneven papillæ. The branchial tube is shorter and stouter, widest at base, truncate at the end, with six, small, obtuse, rounded papillæ surrounding the orifice; outside of these there are six, short, triangular lobes; below these there is often an irregular circle of about six to twelve rougher papillæ, alternately larger and smaller, and sometimes other more irregular ones below, between the sulcations; these are, however, sometimes wanting, as in the specimen figured. In contraction the tubes form low, rough verrucæ, the anal often four-lobed, both covered with rough, irregular papillæ.

1.



The inner tunic, which is closely adherent to the outer, is smooth, pellucid, light greenish, the dark intestine and a reddish organ below it showing through.

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* The figure represents them as arising nearer together than is usually the case.

In life the body and tubes are pale yellowish green or olive; the branchial orifice is sometimes surrounded within by a ring of dull reddish brown, the six lobes have each a spot of dark brown, with smaller ones between. The anal orifice is greenish yellow.

Diameter of the largest specimens seen, about 1 inch.

New York Harbor,—Dekay; Fire I., Long Island, abundant on eel-grass,—S. I. Smith; New Haven Harbor, on eel-grass, abundant,—A. E. Verrill; near New Haven Light on sea-weed, and at Savin Rock, under stones at low-water mark,—A. E. Verrill.

Molgula pannosa Verrill, sp. nov. Figure 2.

Body subglobular, or a little elongated, somewhat compressed laterally, entirely covered, except the ends of the tubes, with a firm and thick covering, composed of fragments of shells, echini, zoöphytes, worm-tubes, foraminifera, grains of sand, pieces of sea-weed, and other debris. The surface of the integument, when the foreign matter is removed, is densely covered with small granule-like papillæ, which give rise to very abundant, long, fine fibrous processes, by which the foreign matters are entangled; the basal portion of the tubes is covered with similar processes, though less numerous, which decrease toward the end, leaving the terminal portion nearly smooth. The tubes, which arise close together, are short, conical, a little divergent. The anal tube is a little longer than the branchial, swollen at base, tapering, and rounded at the end, which has a very small square aperture. The branchial tube is about the same in size, but a little shorter, subcylindrical, scarcely tapering, with six, small, prominent, acute lobes or papillæ; alternating with these are six much smaller ones. In contraction the tubes can be wholly withdrawn, and then the body looks like a more or less irregular ball of dirt.

2.

In life the color of the clean integument is a dull, dark, grayish green; the tubes lighter, or dull olive-green.

A large specimen, when expanded, was 1 inch in length; ·75 broad; ·50 thick.

Eastport, Me., 10 to 50 fathoms, muddy and shelly bottoms, —Expeditions of 1868 and 1870; off Head Harbor, Campo Bello I., 80 fathoms, muddy,—Expedition of 1868.*

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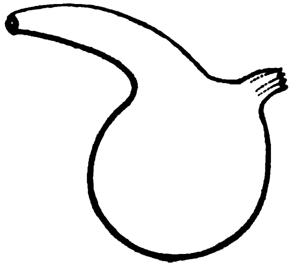
* The expeditions of 1859 and 1863 were by the author; that of 1864 by the author and S. I. Smith; that of 1868 by A. E. Verrill, S. I. Smith, H. E. Webster and Geo. A. Jackson; that of 1870 by A. E. Verrill, Oscar Harger and C. H. Dwinelle.

Molgula retortiformis Verrill, sp. nov. Figure 3.

3.



Body subglobular or more or less oval, generally higher than broad and a little compressed laterally, destitute of a distinct disk, though generally adhering. The integument is thick and firm, but translucent, usually covered, together with the tubes, by various zoöphytes, ascidians, fragments of shells, etc., which form a coarse, rough, and rather loosely adherent coating, but this is usually incomplete or thin and the surface more or less exposed. When cleaned the surface is roughened by small, scattered, granule-like papillæ, and irregular rough processes, while in large specimens it is more or less rudely wrinkled. The large tubes arise from the upper part, a short distance apart, and are widely divergent and very unequal. The anal tube is much the longest, usually equalling in length the diameter of the body, very large and swollen at the base, curving outward and tapering to the end, which is blunt, with a small square aperture, its surface is often roughened with irregular processes, and in partial contraction is often sulcated. The branchial tube is usually about one-fourth as long, much smaller at base, curved outward, the aperture surrounded by six, short, conical, acute papillæ or tentacular lobes, its surface below often rough with irregular verrucæ. In contraction the tubes form large, low and rough verrucæ, or may be wholly retracted and invaginated, together with a portion of the integument of the body around their bases.

When living the color is uniform light olive, or grayish green.

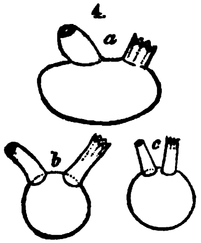
The larger specimens are often 1·50 inches in diameter; with the anal tube nearly 2 inches long; the branchial about ·50. In the collection there are specimens of all sizes from this down to less than ·25 of an inch in diameter.

The young have essentially the same characters as the adults, but are smoother.

Eastport Harbor, South Bay, etc., from extreme low-water of spring tides to 50 fathoms, on rocky and shelly bottoms, adhering loosely by the sides, to other ascidians, zoöphytes, shells, etc., not abundant, though often met with,—Expeditions of 1864, '68, and '70; off Head Harbor, 80 to 120 fathoms,—Exp. 1870.

Molgula littoralis Verrill, sp. nov. Figure 4, a.

Body transversely oblong-oval, somewhat flattened laterally, and attached obliquely by a part of one side (usually the right) to the under side of stones; when young subglobular. Integument firm and tough, but translucent, the tubes similar to the body; the surface smoothish in young specimens, in older ones slightly wrinkled, not fibrous, but somewhat roughened with sparse granule-like papillæ, to which a thin, imperfect coating of foreign substances is sometimes attached; in contraction the surface is reticulated with wrinkles, with more elevated interstices. Tubes short and stout, arising from the upper side, and separated by a distance about equal to or exceeding their diameters, quite divergent, the anal tube most so, not wholly retractile. The anal tube is about twice as long as the branchial and usually swollen in the middle, rounded at the end, with a simple square orifice, which in full expansion often becomes roundish. The branchial tube has about the same diameter, and is short, cylindrical, with six short conical papillæ around the orifice. In contraction the tubes form low verrucæ.



When living the color of the body is translucent, dull greenish or olive, between the tubes usually more or less ferruginous brown, or russet; on the sides the viscera show through as dull orange-colored and darker blotches.

One of the larger specimens was, while living, ·45 of an inch long; height ·35; length of branchial tube ·10; diameter ·10; distance between bases of tubes ·08.

Eastport, Me., under stones near low-water mark, not uncommon,—Expeditions of 1868 and 1870.

In Binney's edition of Gould's Invertebrata of Massachusetts, there are three figures, reproduced from Mr. Burkhardt's drawings, which Mr. Binney refers somewhat doubtfully to *Glandula mollis* Stimpson, neither of which can represent that species. Of these, Fig. 317 (Pl. xxii) may, perhaps, represent the present species, but the apertures show no details.

Molgula papillosa Verrill, sp. nov. Figure 4, *b*.

Body free, nearly globular, or transversely suboval, usually slightly compressed laterally. Integument rather thin, translucent, the surface, both of the tubes and body, entirely covered by particles of sand, broken shells, foraminifera, etc., which adhere firmly. When cleaned the whole surface is thickly covered with prominent granule-like papillæ and numerous slender fibrous processes; the granules are most conspicuous on the tubes, where they usually have a rusty color. The tubes are long, subequal, and their bases are separated by a space usually greater than their diameters; they are quite divergent, both of them curving outward, the anal tube most abruptly. The branchial tube is cylindrical, somewhat longer than the anal, equal to or exceeding the diameter of the body, the orifice surrounded by six, rather long and slender, conical, divergent papillæ. The anal tube often bends suddenly outward, tapers slightly, and has a small square aperture, surrounded by a circle of dull reddish brown. In contraction the tubes are not retracted, but are usually shortened to about one-half their length. In life the body, when cleaned, is pale grayish, with an almost transparent integument, through which the convolutions of the dark intestine are conspicuous.

The largest specimens are about ·40 of an inch in diameter.

Eastport, at low-water mark under stones, and off the northern side of Treat's Island, in 10 to 20 fathoms, shelly bottom,—Expedition of 1870.

Molgula pilularis Verrill, sp. nov. Figure 4, *c*.

Body unattached, globular, covered with a thin layer of mud, and when the tubes are retracted, looking like a small soft ball. Integument of the body, when cleaned, very thin, soft, nearly transparent, thickly covered with minute granules, and minutely fibrous, usually concealed by the adhering particles of mud and fine sand, but this can be easily removed. The tubes are naked, smooth, nearly transparent, subconical, slender, nearly as long as the diameter of the body, originating close together, and but slightly divergent, both of them nearly straight; they can be wholly retracted and their bases are surrounded and connected by a narrow, naked, oval or oblong band, which is usually conspicuous when the tubes are withdrawn; in partial contraction, the tubes are conical, subpellucid, reticulated with white lines. The branchial tube is a little shorter than the anal, the aperture surrounded by six, acute, conical papillæ, and twelve, small, dark brownish spots. Anal tube a little smaller, slightly longer, a little tapering, with a small square aperture, surrounded by four small lobes and four small, reddish brown eye-spots.

In life the body, when cleaned, is transparent grayish, the dark intestine showing through very distinctly; tubes greenish at base.

Diameter usually about ·20 of an inch, seldom more than ·25 or ·30.

Eastport Harbor, in 10 to 20 fathoms, muddy, common,—Expeditions of 1864, '68, '70; South Bay, Lubec, in 6 fathoms, soft mud, very abundant,—Exp. of 1868; Grand Menan, off Swallow's Tail, 15 to 20 fathoms, soft mud,—Exp. of 1870.

Cynthia glutinans Möller (Kroyer's Naturhistorisk Tidsskrift, iv, p. 94, 1842) seems to resemble this species in form and appearance, but if it belongs to *Cynthia*, or to *Glandula* where Stimpson refers it, both apertures must be square. *G. mollis* *Stimp.* must be a closely allied species, if not identical.

(To be continued.)

SCIENTIFIC INTELLIGENCE.

I. CHEMISTRY AND PHYSICS.

1. *Thermo-chemical investigations.*—Under this title J. THOMSEN in Copenhagen, has published a series of valuable researches, the principal results of which, in the author's own language, are as follows:

(1.) As a general law it appears that for all acids

a. When a molecule of sodic hydrate in aqueous solution acts upon an acid the evolution of heat is very nearly proportional to the quantity of acid until this amounts to 1, $\frac{1}{2}$, $\frac{1}{3}$ or $\frac{1}{4}$ of a molecule, according as the acid is one-, two-, three-, or four-basic.

b. But when the quantity of acid exceeds that which is necessary to form the normal salt, a difference between the acids is exhibited, so that according to the constitution of the acid the heat* produced by its excess is either zero, positive or negative.

(2.) *a.* When a molecule of an acid in aqueous solution acts upon sodic hydrate the evolution of heat in a majority of cases is approximately proportional to the quantity of soda until this amounts to 1, 2, 3 or 4 molecules of sodic hydrate according as the acid is one-, two-, three-, or four-basic. The deviations from this law find an explanation in what is stated under heads 1—6.

b. But if the quantity of soda is increased above this, no material change occurs in the heat-toning.

(3.) If the magnitude of the molecule is determined in some other manner, the basicity of the acid, if indeed it has such, may be certainly found by this method of investigation.

(4.) From this it distinctly appears that sulphydric acid is monobasic and that its formula must be considered $H.SH$; since the second atom of hydrogen cannot in an aqueous solution be replaced by sodium. This result which at first sight appears strange is seen upon closer consideration to correspond completely with the more recent chemical theories, since on the one hand it perfectly explains the behavior of the acid, and on the other presents a material support to the theory of hydroxyl, as the great analogy between sulphur and oxygen renders it extremely probable that the formula of water must then be $H.\Theta H$, and that water is to be regarded as a mono-basic acid. It follows also that the so-called neutral metallic sulphides, e. g., Na_2S, do not exist in an aqueous solution, any more than the corresponding oxides ($Na_2\Theta$), and that the so-called sulphydrates, $Na.SH$, $Ba.2SH$, and $Mg.2SH$, are to be regarded as normal salts of the acid soluble in water.

(5.) Since the mono-basic acids contain only one atom of hydrogen replaceable by sodium, the second molecule of sodic hydrate must be without action upon the sodium salt, which is fully verified by experiment. Since further the mono-basic acids form no acid salts, an excess of acid must be without action upon the sodium salt, which is also verified by experiment. In strictness the second molecule of acid produces almost always a slight *toning* of the heat, generally an absorption of heat, but this amounts to only a couple of thousandths of the heat of neutralization. In the case of fluohydric acid we find an exception, since the second molecule of acid produces an absorption of two per cent of the heat of neutralization. This fact and the existence of the acid fluoride of sodium make it doubtful whether fluohydric acid belongs to the mono-basic acids. The numbers for meta-phosphoric and hypophosphorous acid also exhibit a slight toning of the heat (about 1 pr. ct.) for the second molecule of acid. But since the numbers for the first acid cannot be sharply determined in consequence of its great liability to change, and since the number for two molecules of the second were accidentally determined by only one experiment, I lay no stress on this deviation from the rule. In the case of fluohydric acid, however, the deviation is fully established.

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* In the original "Wärmetönung," *heat-toning.*

(6.) The bibasic acids which contain two atoms of hydrogen replaceable by sodium may be divided into several groups according to the quantity of heat which the first and second molecules of sodic hydrate evolve.

The first group embraces the bibasic hydrogen acids—fluosilicohydric acid, SiF_6H_2, and chlorplatinhydric acid, $PtCl_6H_2$; in these there is no noteworthy difference in the quantity of heat which the first and the second molecule of sodic hydrate produces; they behave therefore like the monobasic hydrogen acids, only the evolution of heat for one molecule of acid increases proportionably to the quantity of soda, up to the second molecule of sodic hydrate.

The second group includes sulphuric, selenic, oxalic and tartaric acids; in the neutralization of these acids the first molecule of sodic hydrate produces a less degree of heat than the second. The difference amounts to 5 to 1800 units.[*]

Sodic hydrate.	Sulph. acid.	Selenic acid.	Oxalic acid.	Tartaric acid.
1. Molecule,	146 ..	148 ..	138 ..	124 ..
2. Molecule,	164 ..	156 ..	145 ..	129 ..

The third group embraces sulphurous, selenious, carbonic and boric acids. In the neutralization of these acids the first molecule of sodic hydrate produces a greater degree of heat than the second: the difference amounts to from 18 .. to 28 ..

Sodic hyd.	Sulphurous acid.	Selenious acid.	Carbonic acid.	Boric acid.
1. Molecule,	159 ..	148 ..	110 ..	111 ..
2. Molecule,	131 ..	122 ..	92 ..	89 ..

In this group belong chromic acid, phosphorous acid and probably also succinic acid. In the reaction of the normal salts of the acids of the second group upon the corresponding acids an absorption of heat occurs, as is easily seen, while the normal salts of the acids of the third group produce in the corresponding reaction an evolution of heat.

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[*] Thomsen omits zeros and figures less than 100, and writes two dots only after the significant figures.

(7.) The tribasic acids exhibit differences similar to those of the bibasic acids, citric acid belonging to the second group, arsenic and orthophosphoric acid to the third. Thus we have

Sodic hydrate.	Citric acid.	Arsenic acid.	Ortho-phosphoric acid.
1. Molecule,	124 ..	150 ..	148 ..
2. Molecule,	126 ..	126 ..	123 ..
3. Molecule,	132 ..	83 ..	69 ..

Hence the second or third molecule of sodic hydrate evolves with citric acid *more*, with arsenic and ortho-phosphoric acid less heat than the first molecule. The difference in the evolution of heat in the second and third molecule of sodic hydrate is besides very large for arsenic and phosphoric acids.

(8.) The three groups which I have established in the class of bibasic acids, and of which two are found also in the class of tribasic acids, have their probable origin in the different constitution of the acids. In fact in the case of a bibasic acid the position of the two atoms of hydrogen replaceable by sodium may be conceived in three different ways. Thus sulphuric acid may be expressed by the following three formulas:

$$S\Theta_4 \left\{ \begin{matrix} H \\ H \end{matrix} \right. , \quad S\Theta_3 \left\{ \begin{matrix} \Theta H \\ H \end{matrix} \right. , \quad S\Theta_2 \left\{ \begin{matrix} \Theta H \\ \Theta H \end{matrix} \right. .$$

The first formula might be most probable if the acid were a hydrogen acid; the second is most probable for an acid whose anhydrid exhibits a slight affinity for water; the third is the formula of a bibasic hydroxylic acid. The constitution expressed by the first formula probably corresponds to that of a bibasic hydrogen acid, as for instance fluosilicohydric and chlorplatinhydric acid.

$$Si\,F_6 \left\{ \begin{matrix} H \\ H \end{matrix} \right. \quad Pt\,Cl_6 \left\{ \begin{matrix} H \\ H \end{matrix} \right. .$$

Sulphurous, selenious, carbonic, chromic and boric acids probably correspond to the second formula. Of these the first four at least easily and spontaneously split into anhydrid and water, so that the hydrates (acids proper) of several can scarcely be prepared at all. We have therefore for the rational formulas of these acids,

$$S\Theta_2 \cdot \begin{matrix} \Theta H \\ H \end{matrix} \quad Se\Theta_2 \cdot \begin{matrix} \Theta H \\ H \end{matrix} \quad C\Theta_2 \cdot \begin{matrix} \Theta H \\ H \end{matrix} , \ \&c.$$

This corresponds entirely with the behavior of the homologues of carbonic acid, like glycolic acid and the other members of the lactic acid series, which are probably diatomic, but usually appear monobasic, as the second atom cannot be easily replaced by sodium, but readily by alcoholic and acid radicals. To the third formula correspond sulphuric, selenic, oxalic and tartaric acids, the formulas of which according with the usual assumption, become as follows:

$$S\Theta_2 \cdot \begin{matrix} \Theta H \\ \Theta H \end{matrix} , \quad Se\Theta_2 \cdot \begin{matrix} \Theta H \\ \Theta H \end{matrix} , \quad C_2\Theta_2 \cdot \begin{matrix} \Theta H \\ \Theta H \end{matrix} ,$$

The analogy of the tribasic and bibasic acids leads for citric acid to the formula, $\text{Є}_6H_5\Theta_4 \,.\, 3\Theta H$, while the formulas for the three modifications of phosphoric acid would be the following:

$$HP\Theta_3 \,.\, \genfrac{}{}{0pt}{}{\Theta H}{H}, \quad 2HP\Theta_3 \,.\, \genfrac{}{}{0pt}{}{\Theta H}{H}, \quad HP\Theta_3,$$

by which the thermic difference between citric acid and the acids of phosphorus and arsenic may be explained in harmony with the prevalent chemical theories.

(9.) Silicic acid is given in the tables (accompanying this paper) as a bibasic acid, but differs materially from the other acids of this group, by being absolutely without any definite point of neutralization. The numbers of table II show, it is true, that the heat which a molecule of the acid evolves with an increasing quantity of soda, increases only very slightly when this exceeds two molecules of sodic hydrate, and table I shows that the evolution of heat increases approximately in proportion to the quantity of acid, until this amounts to ½ molecule of silicic acid for one molecule of sodic hydrate. But table II shows at the same time that the numbers by no means increase in proportion to the quantity of soda, and table I also shows that the evolution of heat increases very materially for further additions of silicic acid. From what was shown in Section IV (Pogg. Ann., Bd. 137, p. 203), it appears that the maximum of heat which a molecule of sodic hydrate can evolve with silicic acid, and which occurs only when the quantity of acid is infinitely great, amounts to 134 . . while for ½ molecule of silica it is only 26 . .; further, that the maximum of heat which is evolved by the action of a molecule of silica upon sodic hydrate, and which also occurs when the quantity of sodic hydrate becomes infinitely great, amounts to only 63 . . while two molecules of sodic hydrate already evolve 52 . . .

(10.) The anomaly in the neutralization of silica has very probably its cause in the simultaneous action of water and silica upon sodic hydrate. According to what has been said under 4, water is to be regarded as a monobasic acid, and sodic hydrate as its sodium salt. If now the sodium salt is attacked simultaneously by the two acids (water and silica), the base divides itself between the two acids in a ratio which depends upon the avidity of the acids and their quantity, (see Sect. 1, Pogg. Ann., Bd. 138, p. 94). If now the avidity of the water for the base is very small in comparison with that of the acid, this decomposes an approximately equivalent quantity of sodic hydrate, and the evolution of heat becomes therefore approximately proportional to the quantity of acid, as is also approximately the case with all other acids. If, on the contrary, the avidity of the water for the base is a quantity which cannot be neglected in comparison with that of the acid, the proportionality in the evolution of heat ceases, and then follows a law which holds good for partial decomposition, (see reference cited). The absorption of heat which takes place when a solution of sodic silicate (and also various other saline solutions) is diluted with water, has probably its cause partly in a partial decomposition of the salt by the water.

(11.) The quantities of heat evolved in the reaction of one molecule of sodic hydrate with one molecule of acid-hydrate in aqueous solution are very different. Fluohydric acid gives the greatest amount of heat (163..); then comes sulphurous acid (159..), hypophosphorous acid (152..), arsenic acid (150..); the different phosphoric acids, phosphorous, selenious, selenic and sulphuric acids give between 148.. and 144.. The evolution of heat is less in the cases of the hydrogen acids of chlorine, bromine and iodine and nitric acid (137..); much less in the cases of boric and carbonic acids (110.. to 111..) while sulphydric, silicic and cyanhydric acids give the smallest amounts of heat. If however we compare the evolution of heat which a molecule of sodic hydrate produces with the quantity of acid necessary to form a normal salt, the order of the series is somewhat different, but here also fluohydric acid occurs with the greatest quantity of heat (163..); then follow sulphuric, selenic and hypophosphorous acids (155.. to 152..), then sulphurous, hyposulphuric, phosphorous and oxalic acids (145.. to 141..), and so we pass gradually down to sulphydric, cyanhydric and silicic acids.

(12.) For some of the acids which I have studied the heat of neutralization had been determined already. The older investigations often show material differences from the numbers determined by me. The determinations of Favre and Silbermann in particular differ greatly. The results of these investigators for chlor-, brom- and iodhydric acids and for nitric and phosphoric acids are from 10 to 12 per cent too high, for instance for the first four acids 151.. to 152.. instead of 137... The cause very probably lies in the inaccurate indications of the mercurial calorimeter employed by them, and I doubt very much whether the experiments recently made with the same apparatus possess a greater accuracy. I have already found several material errors in the published results to which I shall return hereafter. For the rest I refer, with reference to the inaccuracy of the results obtained with mercury, to my communication in the Reports of the German Chemical Society at Berlin, 1869, p. 701. W. G.

II. GEOLOGY AND NATURAL HISTORY.

1. *Notes on the American Mastodon and other fossils;* by Dr. J. LEIDY (Proc. Acad. Nat. Sci. Philad., Sept. 1870).—Dr. Leidy, after brief notes on the specimens of Mastodon in Boston and Cambridge, makes the following observations on some bones in the Museum of Amherst College.

Prof. Shepard has recently collected together many interesting fossil remains of vertebrates. Among these are a multitude of specimens obtained by his son from St. Helena Island, and the famous Ashley River deposits of South Carolina. Those from the latter locality consist mainly of Zeuglodons, Cetaceans and Fishes, but also include remains of Mastodon, the Elephant, and of *Equus Major* and *E. fraternus.* The St. Helena Island fossils consist of bones, fragments of jaws and teeth of the Mastodon.

Among them were noticed two inferior tusks, which measured about ten inches in length and two inches in diameter at the base.

The same collection contained a large molar of the American Elephant, of the coarse plated variety, from California. Some remains of Mastodon from the latter place struck me from their peculiarity, and these Prof. Shepard was so kind as to loan to me for examination and description.

One of the specimens, which lies on the table, is the fragment of a tusk from "Dry Creek," Stanislaus Co., California. It indicates a species totally different from the American Mastodon, and in its peculiarities exhibits a relationship with the *Mastodon angustidens* of the middle tertiary period of Europe. The fragment is six inches in length, is slightly curved in two directions, and in transverse section is ovate with the anterior pole acute. The pulp cavity, opening half the diameter at the broken base of the specimen, extends about half its length to the end. The convex side of the tusk possesses, as in *Mastodon angustidens*, a broad band of enamel, which reaches from the acute edge more than two-thirds the depth of the surface. The enamel is somewhat rugose and is two-thirds of a line thick. At one spot, toward the smaller end of the fragment, it has been irregularly worn through for the extent of about an inch and a half. The opposite side of the specimen, from the acute edge, has been worn off to an extent about equal to two-fifths of the surface. The broken ends of the fragment exhibit very conspicuously the beautiful arrangement of decussating curved lines so characteristic of the ivory in the tusks of the great proboscidians.

The vertical diameter of the base of the fragment is 28 lines, the transverse diameter 19 lines; the vertical diameter at the opposite end is 22 lines, the transverse diameter 16 lines. The entire length of the tusk appears to have been less then two feet.

The question arises as to what species the tusk fragment shall be attributed. It certainly does not belong to the common American Mastodon, nor is it probable that it belonged to the pliocene *Mastodon mirificus.* May it probably pertain to the hardly known *Mastodon obscurus?* In the present uncertainty I would look on the specimen as characteristic of a peculiar species allied to the *M. angustidens* of Europe. For the name of the species I would propose that of *Mastodon Shepardi*, in honor of Prof. C. U. Shepard, whose name has so long been identified with the interests of natural history.

The second specimen, exhibited to the members, consists of a fragment of a lower jaw containing the last molar tooth, and was discovered in Contra Costa county, California. No information in regard to the age of the deposit, or the character of the locality in which the fossil was found, accompanies it. The bone is friable, and measures, below the position of the tooth, five and a half inches in depth. Attached to the fossil there is a portion of soft gray rock, part of the matrix in which it has been imbedded. The tooth is perfect and well preserved. It has the same general form and constitution as the corresponding tooth of the American

Mastodon, but is considerably smaller. It bears sufficient resemblance to the plaster cast (represented in fig. 14, pl. xxvii., of "The Extinct Mammalian Fauna of Dakota and Nebraska, &c."). of a tooth, the original of which is lost, from a miocene formation of Maryland, to be viewed as pertaining to the same species. This I had named *Mastodon obscurus*.

The crown of the tooth consists of four transverse divisions together with the merest trace of a heel. As in the cast of the Maryland tooth, the inner lobes of the crown of the California tooth are more mammillary, and less angular than in *M. Americanus*. The outer lobes, likewise as in the Maryland tooth, have better developed offsets fore and aft internally than in the latter, giving rise to a greater degree of obstruction of the transverse valleys of the crown than in the American Mastodon. The fourth division of the crown is proportionately less well developed, in comparison with those in advance, than in the latter, agreeing also in this respect with the Maryland tooth. The outer lobe of this division is formed of a pair of connate mammillary tubercles, as in the latter, but the tubercles are more equally developed. The inner lobe is a single mammillary eminence not more than half the elevation of the outer lobe. In the Maryland tooth, the corresponding lobe resembles the outer one, consisting of a connate pair of tubercles as well developed as in the outer lobe. The heel in the California tooth, as in the Maryland tooth is formed by a short mammillary eminence occupying the angular space posteriorly of the lobes of the fourth division of the crown. A basal ridge is better developed externally in the California than in the Maryland tooth.

Comparative measurements of the California tooth, with the cast of the Maryland tooth, and one of the *Mastodon Americanus* are as follows:

	California tooth.	Maryland tooth.	Mastodon Americanus.
Fore and aft diameter of the crown of the last molar tooth,	6 in. 4 lines.	6 in. 4 lines.[*]	7 in. 3 lines.
Transverse diameter of do.,	2 in. 9 lines.	2 in. 9 lines.	3 in. 4 lines.
Depth of do. internally,	2 in. 2 lines.	2 in. 2 lines.	3 in. 0 lines.

It is not improbable that the California tooth may have pertained to the same species as the fragment of tusk previously noticed, and, perhaps these, together with the Maryland tooth, and others previously referred to *Mastodon obscurus*, may likewise belong to the same animal. The positive determination of this question must be left for the discovery of additional material to throw light on the relationship of the different specimens which have been thus far presented to our notice.

2. *On the cause of the Motion of Glaciers;* by J. Croll, of the Geol. Survey of Scotland, (Phil. Mag., Sept., 1870).—Mr. Croll closes his article on the cause of the motion of glaciers with the following—*on the present state of the question*, and on the *alleged limit to the thickness of a glacier.*

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[*] Partially estimated, as the specimen is imperfect at its fore part.

The present state of the question.—The condition which the perplexing question of the cause of the descent of glaciers has now reached seems to be something like the following. The ice of a glacier is not in a soft and plastic state, but is solid, hard, brittle, and unyielding. It nevertheless behaves in some respects in a manner very like what a soft and plastic substance would do if placed in similar circumstances, inasmuch as it accommodates itself to all the inequalities of the channel in which it moves. The ice of the glacier, though hard and solid, moves with a differential motion; the particles of the ice are displaced over each other, or, in other words, the ice shears as it descends. It had been concluded that the mere weight of the glacier was sufficient to shear the ice. Canon Moseley has investigated this point, and shown that it is not. He has found that for a glacier to shear in the way that it is supposed to do, it would require a force some thirty or forty times as great as the weight of the glacier. Consequently, for the glacier to descend, a force in addition to that of gravitation is required. What, then, is this force? It is found that the rate at which the glacier descends depends upon the amount of heat which it is receiving. This shows that the motion of the glacier is in some way or other dependent upon heat. Is heat, then, the force we are in search of? The answer to this, of course, is, since heat is a force necessarily required, we have no right to assume any other till we see whether or not heat will suffice. In what way, then, does heat aid gravitation in the descent of the glacier? In what way does heat assist gravitation in the shearing of the ice? There are two ways whereby we may conceive the thing to be done: the heat may assist gravitation to shear, by pressing the ice forward, or it may assist gravitation by diminishing the cohesion of the particles, and thus allowing gravitation to produce motion which it otherwise could not produce. Every attempt which has yet been made to explain how heat can act as a force in pushing the ice forward, has failed. The fact that heat cannot expand the ice of the glacier may be regarded as a sufficient proof that it does not act as a force impelling the glacier forward; and we are thus obliged to turn our attention to the other conception, viz., that heat assists gravitation to shear the ice, not by direct pressure, but by diminishing the cohesive force of the particles, so as to enable gravitation to push the one past the other. But how is this done? Does heat diminish the cohesion by acting as an expansive force in separating the particles? Heat cannot do this, because it cannot expand the ice of the glacier; and besides, were it to do this, it would destroy the solid and firm character of the ice, and the ice of the glacier would not then, as a mass, possess the great amount of shearing-force which observation and experiment show that it does. In short it is because the particles of the ice are so firmly fixed together at the time that the glacier is descending, that we are obliged to call in the aid of some other force in addition to the weight of the glacier to shear the ice. Heat does not cause displacement of the particles by making the ice soft and plastic; for we know that the ice of the glacier is not soft and plastic, but hard and brittle. The shearing-force of the ice of the moving glacier is found to be by at least from thirty to forty times too great to permit of the ice being sheared by the mere force of gravitation; how, then, is it that gravitation, without the direct assistance of any other force, can manage to shear the ice? Or to put the question under another form: heat does not reduce the shearing force of the ice of a glacier to something like 1·3193 lb. per square inch of surface, the unit required by Mr. Moseley to enable a glacier to shear by its weight; the shearing-force of the ice, notwithstanding all the heat received, still remains at about 75 lbs.; how, then, can the glacier shear without any other force than its own weight pushing it forward? This is the fundamental question; and the true answer to it must reveal the mystery of glacier-motion. We are compelled in the present state of the problem to admit that glaciers do descend with a differential motion without any other force than their own weight pushing them forward; and yet the shearing-force of the ice is actually found to be thirty or forty times the maximum that would permit of the glacier shearing by its weight only. The explanation of this apparent paradox will remove all our difficulties in reference to the cause of the descent of glaciers.

There seems to be but one explanation (and it is a very obvious one), viz., that the motion of the glacier is *molecular*. The ice descends molecule by molecule. The ice of a glacier is in the hard crystalline state, but it does not descend in this state. Gravitation is a constantly acting force; if a particle of the ice lose its shearing-force, though but for the moment, it will descend by its weight alone. But a particle of the ice will lose its shearing-force for a moment if the particle loses its crystalline state for the moment. The passage of heat through ice, whether by conduction or by radiation, in all probability is a molecular process; that is, the form of energy termed heat is transmitted from molecule to molecule of the ice. A particle takes the energy from its neighbor A on the one side and hands it over to its neighbor B on the opposite side. But the particle must be in a different state at the moment it is in possession of the energy from what it was before it received it from A, and from what it will be after it has handed it over to B. Before it became possessed of the energy, it was in the crystalline state—it was ice; and after it loses possession of the energy it will be ice; but at the moment that it is in possession of the passing energy is it in the crystalline or icy state? If we assume that it is not, but that in becoming possessed of the energy, it loses its crystalline form and for the moment becomes water, all our difficulties regarding the cause of the motion of glaciers are removed.* We know that the ice of a glacier in the mass cannot become possessed of energy in the form of heat without becoming fluid; may not the same thing hold true of the ice particle?

The alleged limit to the thickness of a glacier.—In his memoir, "On the Mechanical Properties of Ice," published in the Philosophical Magazine for January, 1870, Canon Moseley arrives at a conclusion in regard to the crushing of ice to which I am unable, without some qualifications, to agree. In his experiments ice was crushed under a pressure of 308·4 lbs. on the square inch, and he concludes that if a glacier is over 710 feet in thickness the ice at the under surface must be crushed by the incumbent weight. Professor Philips also made some experiments on the crushing of ice, and he came to the conclusion that the height of a crushing column of ice is between 1000 and 1500 feet, and concluded also that if a glacier were to exceed this in thickness the ice would lose its solidity.* Whether the height of a crushing column of ice be 710, or 1000, or 1500 feet is of no consequence whatever as regards the possible thickness of a glacier. No doubt a piece of ice solidified not under pressure would be crushed to powder were it placed under a glacier 1000 feet in thickness or so; but after being crushed it would resolidify, and would then probably be able to sustain a pressure of 2000 feet of ice. This follows as a necessary consequence from the property of regelation. There is as yet, so far as I am aware, no known limit to the amount of pressure which ice may sustain. There probably is a limit; but what that limit is has not yet been determined. Canon Mosely says that "there is no glacier alleged to have so great a depth as 710 feet." The Humboldt glacier in North Greenland, according to Dr. Kane, has a depth of more than three times 710 feet. And Dr. Hayes found in Baffin's Bay icebergs (which are just pieces broken off the ends of glaciers) aground in about half a mile of water. And on the antarctic continent we have reasons for believing that the ice is in some places over a mile in thickness.†

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* See Phil. Mag. for March 1869, p. 201.

3. *On Eozoon Canadense*; by Prof. Wm. King, S.C.D., and Thos. H. Rowney, Ph.D., of the Queen's Univ. in Ireland, and the Queen's College, Galway. 42 pp. 8vo, with three colored plates, (Proc. R. Irish Acad., July 12, 1869). Professors King and Rowney have here discussed anew the nature of the so-called Eozoon, with many additional observations, and argue for their former conclusion, that the Eozoon is of mineral origin alone. The closing paragraph of the memoir, here cited, gives some idea of their view.

Finally, to subscribe to the organic origin of "*Eozoon*," the *chemist* must become a believer in *quasi*-alchymy, and in *direct* oceanic precipitations unknown in nature. The *mineralogist* must assume certain obscure and insufficiently tested bodies to consist of calcite: he must be inappreciative of the various allomorphs of serpentine, and of pseudomorphic phenomena; and consider every imbedded crystalline body—"tuberculated," or "segmented"—"cylindrically shaped," or with angles rounded off—to be the remains of an organism. The *palæontologist*, besides slighting all he knows of the circumstances of petrifaction, must accept as a "fossil" a production never found in rocks that ought to contain it. Even the *zoologist* must believe to be a "*nummuline* foraminifer" what is structurally an *Impossibilitas Naturæ*, in having a "canal system" and "skeleton" that often "*run wild*" without either "chambers" or a "cell wall"; and in being seldom otherwise than *inconceivably* the result of pseudopodial tubulation.

* Paper on Glacial Striation read before the Geological Section of the British Association, 1865.

† Geological Magazine for June, 1870, p. 276.

4. *On Fossil Remains of Mammals found in China*, by Prof. OWEN, (Q. J. Geol. Soc., for Aug., 1870).—Prof. Owen describes in this paper the following species: 1. *Stegodon Sinensis* Ow., from a tooth obtained "from marly beds in the vicinity of Shanghai, probably Tertiary," (belonging to the group of Elephants called "transitional forms" by Owen in his Odontography, which Falconer defined and named Stegodon); 2. *S. orientalis* Ow., said to be "from a cave near the city of Chung-tung-foo, Province of Szo-chuen," and having a more recent aspect than the tooth of *S. Sinensis*; 3. *Hyæna Sinensis* Ow., from specimens supposed to come from a Chinese cavern; 4. *Rhinoceros Sinensis* Ow., probably from the same cavern; 5. *Tapirus Sinensis* Ow., id.; 6. *Chalicotherium Sinensis* Ow., id. The specimens, excepting that of the *S. Sinensis*, were obtained by Mr. Swinhoe from apothecaries in China; and Prof. Owen observed that out of the great quantity of fossils that had thus come into his hands, he had selected for description those agreeing in chemical and other characters, and which "might justly be inferred to be of the same age, and to be derived from the cave mentioned by Mr. Swinhoe."

5. *Diamonds of South Africa.*—According to Dr. JOHN SHAW. as we learn from *Nature*, Nov. 3, the Vaal region, now famous for its diamonds, contains syenite and other metamorphic rocks, quartzite, micaceous sandstones, and clay schists, with trap or basalt and trap conglomerate. The diamonds are found in alluvial gravel, and this gravel contains pebbles of quartzite, granite, clay-slate, garnet, tourmaline, spinel, agate, iron pyrites, the whole waterworn and polished, and imbedded, at Klipdrift, in a brownish fatty clay. Diamonds have been found two hours distance from Potchefstroom, and all down the Vaal to its junction with the Orange river, and thence to ten hours distance below Hope Town, a range of at least 500 miles. Dr. Shaw is of the opinion that the diamonds have come "from some rock which may now have vanished, but which existed formerly through the whole region." The old diggers prefer for their washings the summits of the Kopjes, where the gravel is of wide extent and is far above the influences of the river. These summits are all basalt. In the hollows no gravel is open to view, it being covered with sand, "the accumulation of present denudation;" and thus far the diggers have not undertaken the labor of carrying off the surface sand for work below. "The present diamond digging of South Africa is therefore only trifling in comparison to what it should and will ultimately be."

6. *Publications of the Geological Survey of India, under the direction of* THOMAS OLDHAM, LL.D.—Published by order of His Excellency, the Governor General of India, in Council.—These publications now include six volumes of Memoirs in large octavo; a thick quarto volume with many plates, under the general title Palæontologica Indica, on the Cretaceous Gasteropoda, by F. Stolicka; another, on the Cretaceous Cephalopoda, by H. F. Blanford and F. Stolicka; and parts of two others, on the Fossil Flora of the Rajmahal Hills, Bengal, by T. Oldham and John Morris, and on the Vertebrate Fossils from the Panchet Rocks, Bengal, by

T. H. Huxley; also brief Annual Reports of the Survey; also Catalogues of the Meteorites, and of some departments of Organic remains in the Museum of the Geological Survey of India. The Survey also issues "Records" of the survey, consisting of short papers, in large 8vo, at intervals of about three months. The first number of the second volume (1869) contains 24 closely printed pages. Subscriptions for the year 4 shillings sterling. The address for the publications of the survey is Superintendent of Geological Survey of India, Hastings street, Calcutta. The present year 1870, is the 15th of the survey.

7. *Geological Survey of California;* Ornithology, vol. I. Edited by S. F. Baird from the manuscript and notes of J. G. Cooper. 592 pages, royal 8vo, with 662 cuts. 1870. (Soon to be issued, and sold by Little, Brown & Co., Boston; uncolored, $10).—This admirable report is far in advance of any similar work on Ornithology hitherto published in this country, if not in Europe, and does great honor both to the state of California and the officers of the Geological Survey. The first volume contains descriptions of all the land birds hitherto found in the region north of Mexico and west of the Rocky Mountains. Each genus is illustrated by a reduced full length cut of one of the species, and by natural size cuts of the wing, tail, bill, and foot, which will render it very easy for any one to recognize each genus, while nearly all the species are illustrated by full size cuts of the heads, often of both male and female. The cuts are nearly all original and have been drawn and engraved with great care and skill. The cuts are, in our estimation, superior both in accuracy and beauty to any hitherto published in any work on ornithology, and are far more satisfactory than the highly colored, but often coarse and inaccurate, lithographs, so often employed to illustrate ornithological works. Much information in regard to the habits and geographical distribution of the species has been contributed by Mr. Cooper. One feature, rather novel in general works on ornithology, though in accordance with the views of many modern ornithologists, is a decided change in the systematic arrangement of the orders and families. The singing birds are placed in the first rank, where they doubtless belong, while the rapacious birds take a much inferior position, next to the Rasores, instead of being placed at the head of the whole class, as is usually the case. An edition with colored illustrations is in course of preparation. V.

8. *Geological Chart of Sweden.*—Sheets 31 to 35 inclusive of the Geological chart of Sweden have recently been issued. Nothing can exceed the beauty and perfection of coloring, or the apparent exactness and fullness of scientific details. As there is no department of art in which this country is more behind hand than that of map coloring, and none of Science so disgraceful to us, as that of Geological Charts, we could wish that a copy of the chart might be in the hands, not only of all Geologists, but also, of all members of Congress and State legislatures. The only commendable geological map ever published on this continent is the Canadian, and that was engraved and printed in Paris.

9. *Delesse's Lithologie des Mers.*—Besides the European chart, noticed in a recent volume of this Journal, Delesse has issued one of North America. It is a beautifully colored chart, and illustrates the lithology of the bottoms of the seas as far as known to him, together with the hydrographic basins. His chartist has not been as careful as is desirable for such work. He has joined the head of the Hudson river above Albany to the Chesapeake; while the Hudson River itself he has dwindled to a little stream rising in western Connecticut. The errors probably crept in through carelessness in tracing off from another chart. But there is other want of exactness, showing that the chart needs careful revision. No text for it has yet been issued.

III. ASTRONOMY.

1. *On the Mass of Asteroids between Mars and Jupiter;* by Prof. DANIEL KIRKWOOD, Bloomington, Indiana.—According to Leverrier, the total mass of the ring of minor planets does not exceed one-fourth of the earth's mass, or $\frac{1}{1200}$th of that of Jupiter. So great a disproportion between two adjacent planets is without a parallel. Is the fact susceptible of a probable explanation?

Were the sun transformed into a gaseous spheroid with an equatorial radius equal to the diameter of the earth's orbit, a large number of the known asteriods would, in perihelio, plunge into the solar mass and be reunited with it. Now this, in all probability, is precisely what occurred soon after the abandonment of the asteroid zone, while the solar nebula was in process of condensation. The powerful mass of Jupiter would produce great eccentricity in parts, at least, of the primitive ring. Large portions of its matter, or a considerable number of minor planets in a state of vapor, may thus have been precipitated upon the sun before the latter had contracted within their perihelion distance. The small mass of Mars may perhaps be accounted for on the same hypothesis.—*Proc. Phil. Soc. Philad*

2. *Astronomical and Meteorological Observations made at the United States Naval Observatory during the year* 1867; published by authority of the Hon. Secretary of the Navy, Commodore B. F. SANDS, Superintendent. Washington, Gov. Printing Office, 1870.—The Astronomical observations of the year 1867 at the Naval Observatory, together with the computed positions of the objects observed, fill over 400 closely printed quarto pages in this volume, and the meteorological observations about 50 pages.

To these results of routine work are added four important reports as appendices.

App. 1. Difference of Longitude between Washington and Havana; by Prof. W. Harkness, U. S. N. App. 2. Observations of the total eclipse of the Sun of Aug. 7th, 1869. App. 3. Positions of the Fundamental Stars, deduced from Washington observations made between the years 1862 and 1867 inclusive; by Prof. S. Newcomb, U. S. N. App. 4. Catalogue of 151 stars in Præsepe, by Prof. A. Hall, U. S. N.

Prof. Harkness gives for the position of Morro Light, lat. 23°

9′ 21″·0 North, lon. 0^h 21^m $13^s·43$ West, or 82° 21′ 20″·4 W. of Greenwich. The latest edition of the Admirality list of lights in the West Indies, gives 82° 22′ 12″ for the longitude, nearly a mile in error.

The second appendix has been noticed in this Journal, (II, vol. xlix, p. 134).

We cannot too highly commend in the management of the Naval Observatory, this practice of publishing memoirs prepared by the Assistant Professors *under the name of the authors.* The personal interest in the careful elaboration of the subjects which is thus secured is of great value to science. This practice has been most injuriously and unjustly departed from in more than one observatory in times past.

IV. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Solar Eclipse of Dec.* 22, 1870.—Congress having appropriated $29,000 to enable the Superintendent of the Coast Survey to observe the total eclipse of the sun, which will be visible on the shores of the Mediterranean on the 22nd of Dec. next, Professor Peirce has organized two parties, one which, under his own lead, will occupy several points in Sicily, while the other, under the direction of Prof. Joseph Winlock, director of the Harvard observatory, will occupy points near the line of totality in Spain.

Prof. Peirce is accompanied by Messrs. C. A. Schott, J. H. Lane and Chas. S. Peirce of the Coast Survey, Major H. L. Abbott and Capt. O. H. Ernst of the U. S. Engineers, Prof. J. C. Watson of the University of Michigan, Dr. C. H. F. Peters of Hamilton College, Prof. W. Eimbeck of St. Louis, and Messrs. H. G. Fitz and D. C. Chapman of New York, the two latter having been provided with outfit and instructions for photographic observations by Mr. Lewis M. Rutherfurd of New York.

Prof. Winlock's party consists of G. W. Dean, assistant in the Coast Survey, Professors C. A. Young of Dartmouth College, E. P. Pickering of the Mass. Inst. of Technology, S. P. Langley of the Western University of Penn. at Alleghany, Mr. Alvan G. Clark of Cambridge, and Mr. O. H Willard, photographer of Philadelphia, together with four aids.

On the part of the U. S. Naval Observatory four observers have also been sent out, viz: Professors S. Newcomb, A. Hall, W. Harkness and J. R. Eastman. J. E. H.

Four parties have left England under the auspices of the British Government, one to Cadiz in charge of Rev. S. J. Perry; one to Gibraltar under Captain Noble; a third to Oran (Algiers) under Mr. Huggins; and a fourth to Sicily, under Mr. Lockyer. "*Nature*" of Nov. 24 states that "Professors Young, Pickering, Newcomb, Peters, Watson, Harkness, and others are at present in London, and are daily affording most valuable information to the Organizing Committee and the various observers." While the British Government were hesitating with regard to sending expeditions for observations Prof. Peirce extended an invitation to the English astronomers to join his parties.

2. *A Topographical Survey of the Hawaian Islands* has been ordered by the Legislature of the Islands, and an appropriation of $5000 made for procuring instruments and meeting the expenses of the first year. Prof. W. D. Alexander of Oahu has been appointed Surveyor General, and is making arrangements for commencing the work. He proposes to measure a base line on the sandy isthmus between East and West Maui, which is six or seven miles wide, and to carry forward the survey as nearly as possible after the methods of the U. S. Coast Survey. Geological and Botanical collections and observations will be made in connection with the survey.

3. *A Central Observatory.*—Prof. H. A. Newton has suggested that an excellent position for the great central observatory of the continent is a few miles east of St. Louis, on the 90th meridian from Greenwich. American time reckoned from such an observatory would differ from Greenwich time just six hours, and American longitudes from standard longitude from Greenwich by ninety degrees. It is believed that there are good locations, as regards atmospheric and other conditions, on that meridian not far from St. Louis.

4. *Telescopes.*—Messrs. Alvan Clark & Sons have received recently two orders for telescopes of about 25-inch object glass; one from Mr. McCormick, and the other from the National Government.

5. *Auroral Belt of Oct. 24–25th.*—An account of the remarkable crimson belt, in the great auroral display of Oct. 24–25th, by Prof. A. C. Twining, is deferred to the next number for want of space.

OBITUARY.

DR. MATTHIESSEN.—The death of Dr. Augustus Matthiessen will be learned with sorrow by those of our countrymen who knew him in Heidelberg, in the years of his student-life; or who received from him afterward in London, the attentions which his kindness of heart made him ready to bestow.

Dr. Matthiessen's mind was peculiarly fitted for scientific research. The acuteness which leads to the perception of truth, detects as well the sources of error and suggests the means by which they may be avoided. With the most persevering industry he had a fondness for experimental enquiry; and as his mind moved easily, he was capable of long continued exertion.

The work which first brought him into notice, was a memoir upon the "Preparation and Properties of the Metals of alkaline Earths," made while yet a student in the laboratory at Heidelberg. Prof. Bunsen had himself obtained the metals lithium and magnesium; to them Dr. Matthiessen now added strontium and calcium. After his return to London he began an investigation of the conducting powers of the metals and their alloys for electricity, which occupied him several years, and was afterwards extended to their conducting powers for heat. He subsequently examined the chemical properties of the alloys of zinc with bismuth and with lead; and an alloy of tin and gold which he had obtained in crystalline form. Upon these subjects he delivered in 1867, a lecture before the Chemical Society of London, which was repeated before the Royal Society in the following year. He also investigated the chemical constitution of the opium bases and their products of decomposition, and made elaborate determinations of the expansion by heat of mercury and water. For his various researches the Royal Society, of which he was early chosen a fellow, awarded him in 1869, its gold medal.

In the fifteen years which comprise his scientific life Dr. Matthiessen published at least twenty-eight memoirs. That he was able to accomplish so much was owing in great part to a judicious economy of time, not the penuriousness which refuses hours of relaxation to days of labor, but to a right choice, of subjects which would repay investigation, and of the most direct means by which the investigation could be carried out. He had also the faculty of availing himself of the powers of others by associating them with his work.

With remarkable acuteness of mind, or shrewdness, Dr. Matthiessen had a sincere and affectionate disposition. Resolved from the first to make his own way, he was always ready to help on others. He was a kind, a firm, a generous friend; generous of his thoughts, his means, and his influence. At the time of his death, no man of his age in England stood in a higher position in science; nor was there one from whose future, judging from his past, more might with reason have been expected. D.

Mr. EDWARD HARTLEY, Mining Engineer of the Geological Survey of Canada, died in Pictou, Nova Scotia, on the 10th of November last, aged twenty-three years. Mr. Hartley was the eldest son of Mr. William M. B. Hartley of New York, and grandson of Mr. Philos Blake of New Haven. He early showed a special aptitude for the study of the natural and physical sciences, and for mechanics. At the age of fifteen he became a student in the Sheffield Scientific School of Yale College. On leaving the school, though still very young, he was at once charged with the examination and surveying of mineral lands in Maryland and Pennsylvania, and subsequently with the erection of machinery for working gold in North Carolina. His abilities attracted the attention of the officers of the Geological Survey of Canada under Sir W. E. Logan, and in July, 1868, he joined the Survey as a geological assistant. The following year he was appointed Mining Engineer to the Geological Survey. His duties from this time confined him to the coal-fields of Nova Scotia, where in 1868 he worked conjointly with Sir W. E. Logan, and in 1869, alone, completing a careful and detailed Survey of the Pictou coal-basin, of which an elaborate report by Sir William and another by himself was printed and privately distributed before his death. It will be published with a map in the forthcoming volume of the Geological Survey.

During 1870, Mr. Hartley was engaged with an assistant in the Survey of the Cumberland coal-basin in Nova Scotia, and of the Cape Breton collieries, and had nearly completed his labors for the season when he died after an illness of but six days duration, brought on, probably, by labors beyond his physical strength.

T. S. H.

EDWIN W. ROOT, Prof. of Chemistry in Hamilton College, died Nov. 15, in the 30th year of his age. On returning to this country in 1865, after his studies in Germany, he was appointed Assistant Professor of Analytical Chemistry in the School of Mines of Columbia College. Afterward, in 1868, he became Professor of Agricultural Chemistry, and the next year of General Chemistry, in Hamilton College. Prof. Root was highly esteemed for his scientific and literary attainments, integrity of character, and tested ability.

V. MISCELLANEOUS BIBLIOGRAPHY.

1. *Storer's (Frank H.) Cyclopædia of Quantitative Analysis;* Part I, 112 pp. 8vo, with an appendix of 8 pages. Boston and Cambridge, 1870. Sever, Francis & Co.—Prof. Storer states in his preface that his object in preparing this book has been not only to provide the student and working chemist with a comprehensive dictionary of quantitative processes, but to show also the possibility of presenting this branch of chemical art in a more serviceable and manageable form than has been customary hitherto: and he adds, 'the experiment is certainly worth trying whether a definite system of classifying substances in alphabetical order, and of referring each and every process to the fundamental fact or *principle* upon which it depends, will not greatly facilitate both the study and the practice of Analysis.' An examination of this first part of Prof. Storer's "Cyclopædia" reveals at once the hand of a master as distinguished from the work of the compiler. The alphabetical order by no means hampers the author's philosophical treatment of subjects. This is particularly well illustrated in the articles "CARBON" and "CARBONIC ACID," where the originality of the method of treatment is surpassed only by the thoroughness of the detail given of all methods, of any value, known to chemists, for the determination of carbon whether as such—as in the analysis of cast-iron and steel—or by its oxidation to carbonic acid and estimation in any mixture or compound. The author's entire familiarity with the whole field of chemical literature has enabled him to render a justice to American researches in analytical chemistry which has never been awarded by any foreign author.

2. *The Story of the Rocks. A Fourteen Weeks' Course in Popular Geology;* by J. DORMAN STEELE, A.M., Ph.D., Principal of Elmira Free Academy, author of a Fourteen Weeks' Course in Chemistry, etc. 280 pp. 12mo. 1871. New York and Chicago. (A. S. Barnes & Co.).—This small geological text-book will be read with interest by those that are not critical, and are satisfied with so brief a presentation of the science. While in many respects well arranged for instruction, and clear in its descriptions, its statements are often wanting in exactness, and its explanations unsatisfactory. The following are a few examples. "Rocks are composed in general of only three common minerals, *Quartz*, *Clay* and *Lime*." But clay is not a mineral; lime should be *limestone*; and granite and all the crystalline rocks have no place under such a definition.

Again, "Oolite is a limestone containing [should be, consisting of, although the bad drawing given sustains the author] numerous, small rounded [add concretionary] grains, resembling the roe of a fish." He says that, "The coral animal thrives best in pure water, about a hundred feet in depth," in place of the fact that reef-forming corals thrive well at low-tide level and at all depths below down to one hundred feet, while other coral animals occur at depths exceeding a thousand feet. The author attributes the "continually vibrating to and fro" of the continent, which finally culminated in the folding of the rocks producing the Appalachians, to "the tremendous pressure of the two oceans during the Carboniferous age." Bad hydrostatics, this. A drawing of an Ichthyosaurus represents him spouting like a Right Whale!

3. *A Text Book of Elementary Chemistry, Theoretical and Inorganic;* by GEORGE F. BARKER, M.D., Professor of Physiological Chemistry in Yale College, New Haven, Conn. vi and 342 pp. 12mo. New Haven, 1870. (C. C. Chatfield & Co.)—Prof. Barker has produced a compact Elementary Text Book, the dimensions of which adapt it to the use of schools, and which is the first in our language wherein "Modern Chemistry" is presented systematically. The style of the work is concise and animated, the illustrations are fresh, the typography is good, and it cannot fail of a hearty welcome among our teachers and learners.

4. *The American Naturalist, a popular Illustrated Magazine of Natural History.* (Salem, Mass. $4.00 a year).—This monthly Magazine of Naturalist History has won for itself a high place among the Journals of the world. It knows how to popularize science without degrading it. Many of its articles are by some of the best zoologists of the country, and contain the results of original observation. The illustrations are always excellent.

A Monograph of N. A. Astacidæ. by Dr. Hermann A. Hagen; No. III, of the Illustrated Catalogue of the Museum of Comparative Zoology of Harvard College. (Published by order of the Legislature of Massachusetts). 112 pp. roy. 8vo, with 11 plates. Cambridge, 1870. To be noticed in our next No.

Students' Manual of Comparative Anatomy, and Guide to Dissection, by G. Herbert Morrell, B.A.. B.C.L. Longmans, Green & Co. Aves, ready. Mammalia promised for November.

Elementary Treatise on Natural Philosophy, by Sir W. Thomson and Prof. Tait. In the press. Macmillan & Co.

The Petroleum Monthly, devoted to the interests of the Oil Business. S. P. Irvin and J. H. Bowman. Editors and Publishers, Oil City, Pa. The first number of this Journal appeared on the first of November. Price three dollars a year.

Catalogue of the Principal Minerals of Colorado, with notes. by J. Alden Smith. 16 pp. 8vo. Central City, 1870.

A Monograph of the Alcedinidæ: or. Kingfishers, by R. B. Sharpe, F.L.S., &c., Librarian to the Zoological Society of London, to be complete in fifteen parts. Price to subscribers, 10s. 6d. each. Annual subscription, £2 2s. Only thirty copies now remain of this work. The price will be raised when the work is completed, which will soon be. Intending subscribers are respectfully requested to send their names to the author. at "The Zoological Society of London," 11 Hanover Square, London, W. Also, uniform with the above, A Monograph of the Capi*tonidæ: or*, Scansorial Barbets by C. H. T. Marshall, F.Z.S., and G. F. L. Marshall, *F.Z.S. To be* completed in nine parts. Price 10*s.* 6*d.* each.

THE
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[THIRD SERIES.]

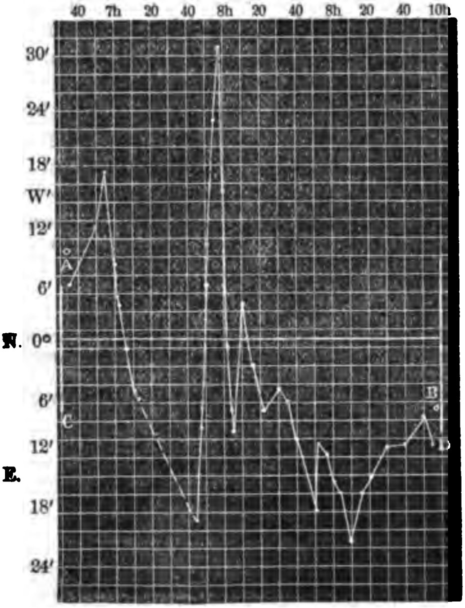
Art. XII.—*Observations on the Variation of the Magnetic Declination in connection with the Aurora of October 14, 1870. With remarks on the physical connection between changes in area of disturbed solar surface and magnetic perturbations;* by Alfred M. Mayer, Ph.D.

The aurora of October 14th was first observed by me at 6^h 30^m P. M. as a ruddy glow in the N.N.E., reaching to about 40° above the horizon. The magnetic observations were commenced at 6^h 35^m. In the following table the first column contains the times of observation in Bethlehem mean time (long. E. Washington 6^m 42^s, lat. N. 40° 36′ 24″), while in the second are given the declinations, + indicating a W. and − an E. movement of the N. end of the magnet in reference to the line of mean declination of the day, taken as the mean of the maximum E. elongation at 8^h 30^m and the maximum W. elongation at 13^h 17^m. This line of mean declination we will call 0°.

Time.	Declination.	Remarks.
6^h 35^m	+ 5′·70	An arch of silvery light in the N., whose sagitta appears to be in the magnetic meridian. Clouds on the horizon partly obscure its outline.
6 50	+11′·46	Arch about 20° in altitude; definition faint. Streamers W.N.W. and E.N.E.
6 56	+18′·37	Aurora the same as at 6 50.
7 00	+ 8′·00	
7 02	+ 4′·55	
7 03	+ 3′·39	
7 6½	− 1′·20	
7 9	− 5′·81	Arch very faint; no streamers.
7 12	− 6′·96 to −5′·81	[altitude.
7 46	−21′·94 to −17′·23	Streamers of crimson hue E.N.E. reaching to 60° in

Time.	Declination.	Remarks.
7h 48m	−12′·72 to −6′·96	Crimson and greenish streamers N.W. to N.E.
7 51½	+ 4′·55 to +8′·	
7 52½	+10′·31 to 11′·46	Greenish streamers extending about 50° above arch.
7 55½	+21′·83 to 25′·28	Aurora nearly the same as at 7h 52½m.
7 57½	+31′·04 to 32′·19	
8 0½	+22′·98 to 17′·22	This easterly motion of the magnet is steady and rapid. At the same time deep rosy streamers flash up in the N.N.W.
8 1¾	− 1′·20	Red streamers have disappeared.
8 3½	− 8′·12	Aurora the same as at 8 —1¾.
8 5¾	−10′·42	Aurora same as above.
8 10	+ 2′·24 to 4′·55	Crimson glow in N.E.
8 16	− 3′·51 to −2′·36	
8 21½	− 9′·27 to −6′·96	Aurora has declined to a faint white arch.
8 30	− 5′·81 to −5′·24	Faint white streamers from the arch.
8 35	− 6′·96	Streamers very faint. Arch ill-defined; moon is rising.
8 40	−12′·72	
8 50	−18′·48	
8 51	−11′·57	Aurora still fainter.
8 55	−13′·30 to 12′·15	" barely visible.
9 00	−15′·60	
9 5	−17′·91	
9 10	−22′·52	Aurora invisible.
9 16	−17′·33	" "
9 20	−15′·03	" "
9 30	−11′·57	" "
9 40	−11′·57	" "
9 50	− 8′·69	" "
10 00	−11′·86	" "

These determinations are here expressed graphically. The ordinates above the 0° line indicate a W., and those below, an E. position of the N. end of the magnet referred to the line of mean declination of Oct. 14. The vertical line C shows the average daily range (12′·85) as given by the mean of the range of the five days before and of the five days after the auroral display; not including in the mean the range of Oct. 14. The line D represents the range (18′·43) of Oct. 14. A is the position the magnet had (+9′·88) at 1h 17m P. M. on Oct. 14, while B is the declination (−7′·25) at 8h (the time of greatest E. elongation) on the morning of Oct. 15.



It will be observed, on referring to the column of "Remarks" in connection with the curve, that the motion of the needle coincided in its maxima and minima with the greatest activity of the aurora; and the rapid and steady easterly motion, from 7^h 57^m·5 to 8^h 5^m·5, of 42′·04, is remarkable. Viewed in the declinometer it appeared exactly as though a distant disturbing body was gradually receding from the magnet. The flashing up of brilliant streamers at the time of the beginning of this easterly motion is also to be noticed.

The magnet used in these observations is a cylindrical bar 8 ins. long 0·4 in. in diameter, attached to a plane mirror 2 ins. square, and suspended by 2 ft. of untwisted silk fibers. The scale is placed 3 meters from the mirror and with the telescope deflections of 10″ can be read.

It is to be remarked that the auroral observations do not comport in accuracy with the observations of declination. Having no assistance, I could only observe from a N. window directly after having obtained the scale readings, therefore there are many phenomena of this aurora, which appeared in the zenith, and S. of E. and W., which I did not observe.

In connection with the above observation, I will here give an account of a systematic work in which I am engaged and which furnishes a few facts related to the subject of this paper.

Every day about 11^h (if clear; if cloudy at the nearest possible time thereto) the mean penumbral diameter,* in seconds, of every spot and tache on the sun is measured. These diameters are then reduced to what they would be if viewed normally. Each of these measures is then squared and *their sum* gives a number which will vary with the umbral and penumbral areas. These daily numbers are therefore directly comparable quantities of the areas of solar disturbance; at least so far as that disturbance is evinced in the formation of spots. Similar measures are made on all the faculæ I can manage. Remarks are also recorded as to changes in spots and faculæ. In connection with the above measures the daily range of magnetic declination is determined to 10″.

The object of this work is to discover, if possible, a more certainly based physical connection between the daily *changes of area* of solar disturbance and the variation of daily range of declination. It seems that if the ten-year cycle of solar spots has a physical connection with the varying mean yearly range of declination, that such a connection can be detected and satisfactorily established—if not in the special cases of ordinary daily variation of declination—at least in the cases of great magnetic disturbances or "storms" either accompanied or not by auroral displays. But, as a spot indicates—if not entirely, at least principally—an effect of an action which has done its work, we must look more minutely to the *changes in area of disturbance.* For, if the connection exist, it will show itself principally *during* the periods of rapid increase or decrease in area of solar disturbance and not when a maximum or minimum area has been reached and remains constant.

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* When the greater diameter equals or exceeds twice that of the lesser the spot is divided into two or more measures.

These remarks are illustrated by measures on the penumbral areas made before and after the auroral displays of the 14th Oct. and of Oct. 24 and 25.

The declination range on Oct. 11, three days before the aurora, was 11′·23 and increased with the area of solar disturbance to the 14th when it reached 18′·43 and the area-number on this day equalled 17075; but on Oct. 15th, the day *after* the aurora, the declination range had *fallen* to 11′·52 while the area-number had reached 18875, showing an increase of 1800 from noon of the 14th to noon of the 15th, *during which interval* the aurora broke forth. On the 16th the range was 11′·52 and the area-number 15795.

On Oct. 21, three days before the auroral display of Oct. 24, the declination range was only 3′·94; the area-number 13748. On Oct. 22, decl. =12′·75; area-number =14732. On Oct. 23, decl.=11′·53; area-number =15991. On Oct. 24, the aurora (as I subsequently learned from the newspapers) was observed at Cincinnati and Cleveland at 5 A. M. I observed myself the great disturbance a few minutes before 8 A. M., when I began my magnetic observations for obtaining the max. E. elongation. At 11 A. M. the measure of solar disturbance gave 16954 and the observed declination range on that day equalled 44′·79. On Oct. 25, it reached 54′·63.* On Oct. 26, the declination range equalled 14′·26 and the area-number had declined to 11959. Here also we observe that the aurora appeared during the period of increase in the penumbral surface.

These facts, brought forward as illustrations of my remarks and not as *proof* of the physical connection of disturbed solar area and magnetic perturbation,—for that will require almost constant coincidences,—show at once wherein lies the difficulty of such a research; a difficulty which seems not to have been appreciated by those who have given their energies more to a mathematical than to a physical analysis of the connection of these phenomena; and that is, the frequent impossibility of fixing the *time* at which such a change in area took place. It is very evident, in the first example, that it took place between noon of the 14th and noon of the 15th, but whether it coincided with the auroral display and magnetic perturbation could only have been determined by means of solar measurements, or photographs, taken at several stations differing greatly in longitude. This shows the absolute necessity of several such stations; and that future research in this direction cannot rely alone on the work of the Kew Observatory. Also, the prevalence of cloudy weather in England, especially during the fall and winter months, will add force to the above opinion.

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* On the 24th the disturbance was greatest between 9 and 10 A. M. On Oct. 25. the greatest perturbations were from 12 M. to 2–56 P. M. During the evening displays of this aurora the needle was only slightly deflected. 113 observations were made by me on this aurora.

Rapid changes in spot-area are well known to all students of the solar surface. A good example occurred in the largest spot in the S.W. quadrant of the sun during the time of the memorable eclipse of Aug. 7, 1869. Measurements on two photographs, taken at intervals of about two hours gave a closing up of the umbra of 2360 miles in a N.E. and S.W. direction. (See my report on the eclipse in Oct. No. of the Jour. of the Franklin Inst.). The astronomer Wallaston says: —"Once I saw, with a 12-inch reflector, a spot burst in pieces while I was looking at it. I could not expect such an event, and therefore cannot be certain of the exact particulars; but the appearance, as it struck me at the time, was like that of a piece of ice when dashed on a frozen pond, which breaks in pieces, and slides on the surface in various directions. I was then a very young astronomer, but I think I may be sure of the fact."

Carrington, Hodgson and Brodie have observed brilliant clouds appear in the neighborhood of spots, and progress with a velocity of over 6,000 miles per minute; while Prof. C. A. Young has recently made a most remarkable spectroscopic observation of two such brilliant clouds—together over 130,000 miles in breadth—which in ten minutes had contracted their dimensions to an enormous extent; this however, judging from analogy, was probably due to vertical motion.

The question now naturally presents itself:—In case this physical connection between the disturbed solar area and the terrestrial magnetic condition exist, in what does it consist? What is the nature of this connection? Is it owing to an inductive action of the sun? if so, the magnetic intensity of a body depending greatly upon the condition of its surface, that inductive action will vary with the character of its surface. If this be the case then we should take into consideration the probable condition of the hidden solar hemisphere, deduced from preceding observations on it where it was visible combined with subsequent ones when it again appeared. But can we apply such reasoning to a body covered with tumultuous gases heated to an enormous temperature? Does not the connection consist in the action of the solar vibrations sent forth from the chief source of all energy? The experiments of Morrichini, Mrs. Somerville, Zantedeschi and others were once viewed as conclusively showing effects produced by these vibrations sufficient, not only to increase the magnetic intensity of natural and artificial magnets, but also to give magnetism to steel needles previously devoid of that property; but the more recent experiments of Riess and Moser[*] cast such doubt over preceding results that the subject has since received but little attention. It is also to be remarked that Faraday, when in Rome with Sir H. Davy in May, 1814, spent several hours at the house of Morrichini, working with his apparatus and under his directions, but could not succeed in magnetizing a needle. Morrichini attributed the failure to the misty state of the atmosphere.

With our present imperfect knowledge of the various forms of energy existing in the solar emanation these questions cannot be answered; but the fact that they can be asked, and the fundamental cosmical relations which will be revealed by their solution, is sufficient to induce men of sicence again to attack this problem,—though its solution baffled all the manipulative ingenuity and philosophical acumen of a Faraday[†]—the correlation of the solar emanations and electricity and magnetism.

ART. XIII.—*Notes on Granitic Rocks;* by T. STERRY HUNT, LL.D., F.R.S. FIRST PART.[‡]

(Read before the American Association for the Advancement of Science at Troy, August 20, 1870.)

CONTENTS OF SECTIONS.—§ 1–2, Definitions of granite and syenite; § 3, Structure of granitic and gneissic rocks; § 4–5, Felsites and felsite-porphyries; § 6, Gneisses and granites of New England; § 7, Granitic dykes and granitic veinstones; § 8, Scheerer's theory of granitic veins; § 9–10, Elie de Beaumont on granites and granitic emanations; § 11, Granitic distinguished from concretionary veins; § 12, Von Cotta on granitic veins; § 13–14, The author's views on the concretionary origin of granitic veins; § 15, The banded structure of granitic veins.

§ 1. THE name of granite is employed to designate a supposed eruptive or exotic unstratified composite rock, granular, crystalline in texture, and consisting essentially of orthoclase-feldspar and quartz, with an admixture of mica, and frequently of a triclinic feldspar, either oligoclase or albite. This is the definition of granite given by most writers on lithology, and applies to a great portion of what are commonly called granitic rocks; there are, however, crystalline granite-like aggregates in which the mica is replaced by a dark colored hornblende or amphibole, and to such a compound rock many authors have given the name of syenite, while to those in which mica and hornblende co-exist, the name of syenitic granite is applied. It is observed that in certain of these hornblendic granites, the quartz becomes less in amount than in ordinary granites, and finally disappears altogether, giving rise to a rock composed of orthoclase and hornblende only. To this binary aggregate von Cotta and Zirkel would restrict the term syenite, which was already defined by d'Omalius d'Halloy to be a crystalline aggregate of hornblende and feldspar, by which orthoclase-feldspar may be understood, since he describes varieties of syenite as passing into diorite, a name by most modern lithologists restricted to a compound of albite or some more basic triclinic feldspar with hornblende. It is apparently by failing to appreciate the distinction between orthoclase and triclinic feldspar in this connection, that Haughton has lately described under the name of syenite rocks composed of crystalline labradorite and hornblende.

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[*] Ann· de Chem. et de Phys., t. xlii, p. 304.

[†] See Life and Letters of Faraday, vol. ii, pp. 301 *et seq.* and p. 351.

[‡] This, with the following part. embraces the matter of the paper read at Troy in August last. It is proposed in the third and fourth parts to describe the Laurentian veins and to consider the subject of eruptive granites.

§ 2. Naumann, regarding orthoclase and quartz as the essential constituents of granite, designates those aggregates which contain mica as mica-granites, and thus distinguishes them from hornblende-granites, in which the mica is replaced by hornblende. These definitions seem the more desirable as the name of granite is popularly applied both to the hornblendic and the micaceous aggregates of orthoclase and quartz. There are not wanting examples of well-defined rocks of this kind in which both mica and hornblende are almost or altogether wanting. Such rocks have been designated binary granites, a term which it will be well to retain. Chloritic and talcose granites, into the composition of which chlorite and talc enter, need only be mentioned in this connection. The name of syenite, so often given to hornblendic granites, will, in accordance with the views already expressed, be restricted to rocks destitute of quartz. While the disappearance of this mineral from hornblendic granites is held to give rise to a true syenite, the same process with micaceous granites affords a quartzless rock, consisting of orthoclase and mica, for which we have no name. Great masses of an eruptive rock, granite-like in structure, and consisting of crystalline orthoclase or sanidin, without any quartz, occur in the province of Quebec. This rock contains in some cases a small admixture of black mica, and in others an equally small proportion of black hornblende. The latter variety might be described as syenite, but for the former we have no distinctive name, and I have described both of these by the name of granitoid trachytes, a term which I adopted the more willingly on account of the peculiar composition of the feldspar, and also because compact and finely granular rocks in the same region, having a similar chemical composition, present all the characters of typical trachytes, and apparently graduate into the granitoid rocks just noticed.* In all attempts to

* This Journal, II, xxxviii, 95. See also Zirkel, *Petrographie*, ii, 179.

define and classify compound rocks, it should be borne in mind that they are not definite lithological species, but admixtures of two or more mineralogical species, and can only be arbitrarily defined and limited.

§ 3. Having thus defined the mineral composition of granitic rocks, we proceed to notice their structure. Gneiss has the same mineral elements as granite, but is distinguished by the more or less stratified and parallel arrangement of its constituents, and lithologists are aware that in certain varieties of gneiss, this structure is scarcely evident except on a large scale; so that the distinction between gneiss and granite rests rather on geognostical than on lithological grounds. To the lithologist, in fact, the granitoid gneisses are simply more or less stratiform granites, while it belongs to the geologist to consider whether this structure has resulted from a sedimentary deposition, or from the flowing of a semi-fluid heterogeneous mass giving rise to a stratiform arrangement.

§ 4. The rocks having the mineralogical composition of granites present a gradual passage from the coarse structure of ordinary micaceous, hornblendic and binary granites to finely granular and even impalpable mixtures of the constituent minerals, constituting the rocks known as felsite, eurite and petrosilex. These rocks are often porphyritic from the presence of crystals of orthoclase, and sometimes of crystals or grains of quartz imbedded in the finely granular or impalpable paste. These felsites and felsite-porphyries are, in very many cases at least, stratified or indigenous rocks, and they are sometimes found associated with granular aggregates of different degrees of coarseness, which show a transition from true felsites into granitic gneisses. The resemblances in ultimate composition between felsites, granites and granitic gneisses are so close that it cannot be doubted that their differences are only structural.

§ 5. Felsites and felsite-porphyries are well known in eastern Massachusetts at Lynn, Saugus, Marblehead and Newburyport, and may be traced from Machias and Eastport in Maine, along the southern coast of New Brunswick to the head of the Bay of Fundy, with great uniformity of type, though in every place subject to considerable variations from a compact jasper-like rock to more or less coarsely granular varieties, all of which are often porphyritic from feldspar crystals, and sometimes include grains or crystals of quartz. The colors of these rocks are generally some shade of red, varying from flesh-red to purple; pale yellow, gray, greenish and even black varieties are however occasionally met with. These rocks are throughout this region distinctly stratified, and are closely associated with dioritic, chloritic and epidotic strata. They apparently belong, like these, to the great Huronian system.

§ 6. Many of the so-called granites of New England are true gneisses, as for example, those quarried in Augusta, Hallowell, Brunswick and many other places in Maine, which are indigenous rocks interstratified with the micaceous and hornblendic schists of the great White Mountain series. To this class also, judging from lithological characters, belong the so-called granites of Concord and Fitzwilliam, New Hampshire. These indigenous rocks are tenderer, less coherent, and generally finer grained than the eruptive granites, of which we have examples in the micaceous granite of Biddeford, Maine, and the hornblendic granites of Marblehead and Stoneham, Mass., and Newport, Rhode Island; in all of which localities the contact of the eruptive mass with the enclosing rock is plainly seen; as is also the case farther eastward, on the St. Croix and St. John Rivers in New Brunswick, and in the Cobequid Hills and elsewhere in Nova Scotia. The hornblendic granites of Gloucester, Salem and Quincy, Massachusetts, seem also, from their lithological characters, to belong to the class of exotic or true eruptive granites.* The farther discussion of the nature and origin of these gneisses and granites is reserved for another occasion, and we now proceed to notice the history of granitic veins.

§ 7. The eruptive granitic masses just noticed, not only include fragments of the adjacent rocks, especially near the line of contact, but very often send off dykes or veins into the surrounding strata. The relation of these with the parent mass is however generally obvious, and it may be seen that they do not differ from it except in being often finer grained. These injected or intruded veins are not to be confounded with a third class of granitic aggregates, which I have elsewhere described as granitic veinstones, or, to express their supposed mode of formation, endogenous granites. They are to the gneisses and mica-schists, in which they are generally enclosed, what calcite veins are to stratified limestones; and although long known, and objects of interest from their mineral contents, have generally been confounded with intrusive granites.

§ 8. Scheerer, in his famous essay on granitic rocks, which appeared in the Bulletin of the Geological Society of France in 1847, (vol. iv, p. 468), conceives the congealing granitic mass to have been impregnated with "a juice," which was nothing else than a highly heated aqueous solution of certain mineral matters. This, under great pressure, oozed out, penetrating even the stratified rocks in contact with the granite, filling cavities and fissures in the latter, and depositing therein crystals of quartz and of hornblende, the arrangement of which shows them to have been of successive growth. Neither Scheerer, nor Virlet d'Aout, who supported his views, however (*ibid.*, iv, p. 493) extended them to feldspathic veins, though Daubrée, at an earlier date, had described certain granitic veins in Scandinavia as having been formed by secretion rather than by igneous injection, as maintained by Durocher.

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* T. S. Hunt on the Geology of Eastern New England, this Journal for July, 1870, p. 88; also Notes on the Geology of the vicinity of Boston, Proc. Boston Nat. Hist. Soc., Oct. 19, 1870.

§ 9. Elie de Beaumont, starting from the hypothesis of a cooling liquid globe, imagined "a bath of molten matter on the surface of which the first granites crystallized." From the ruins of these were formed the first sedimentary deposits, but directly beneath were other granitic masses, which became fixed immediately afterward. "Some parts of these masses, coagulated from the commencement of the cooling process, but not completely solidified, were then erupted through the sedimentary deposits" just mentioned. "In these jets of pasty matter" were contained many of the rarer elements of the granitic magma, which were thus concentrated in the outermost portions of the granitic crust, and in the ramifications formed by these portions in the masses through which they were forced by the eruptive agents. Those portions of the granitic masses, and their ramifications, in which these rarer elements are concentrated, are distinguished from the rest of the masses alike by their exterior position and their peculiar structure. They are often coarse-grained and include the pegmatites, tourmaline-granites, and veins carrying cassiterite and columbite, often abounding in quartz. These mineral products are to be regarded as emanations from the granite, and are described as a *granitic aura*, constituting what Humboldt has called the penumbra of the granite. (*Bull. Soc. Geol. de France*, (2) iv, 1249. See particularly pages 1295, 1321 and 1323).

§ 10. While Fournet, Durocher and Rivière conceived the granitic magma to have been purely anhydrous, and in a state of simple igneous fusion, Elie de Beaumont maintained with Poulett-Scrope and Scheerer that water had in all cases intervened, and that a few hundredths of water might at low red heat have given rise to the condition of imperfect liquidity which he imagined for the material of the injected granites. The coarsely crystalline granitic veins were according to him veins of injection, and he speaks of them as examples in which "the phenomena essential to the formation of granite had been manifested with the greatest intensity." The granitic emanations, which are supposed to have furnished the material of these veins, appear to be regarded by him as the result of a process of eliquation from the congealing granitic mass. De Beaumont is careful to distinguish between them and those emanations which are dissolved in mineral waters or are exhaled as volcanic vapors, (page 1324). To the agency of such waters he ascribes the formation of concretionary veins, which are generally characterized by their symmetrically banded structure.

He further adds that granites, as to their mode of formation, offer a character intermediate between ordinary veins and volcanic and basic rocks. This is conceivable as regards granitic veins, since these, according to him, although formed by injection, and not by concretion, result from a process of emanation from the parent granitic mass, which may be described as a kind of segregation.

I have thus endeavored to give, for the most part in his own words, the views on the origin of granites enunciated by the great French geologist in his classic essay on Volcanic and Metalliferous Emanations, published in 1847. They belong to the history of our subject, and are remarkable as a clear and complete expression of those modified plutonic views which are probably held by a great number of enlightened geologists at the present time. My reason for dissenting from them, and the theories which I offer in their stead will be shown in the sequel.

§ 11. Élie de Beaumont, while regarding the formation of granitic veins as a process in which water intervened to give fluidity to the magma, was careful to distinguish the process from that of the production of concretionary veins from aqueous solution, and supposed the fissures to have been filled by the injection of a jet of pasty matter, derived from a consolidating granitic mass. Daubrée and Scheerer in describing the granitic veins of Scandinavia, conceive the material filling them to have been derived from the enclosing crystalline strata instead of an unstratified granitic nucleus, but do not, so far as I am aware, compare their formation to that of concretionary veins. Their publications on this subject, it should be said, are both anterior to the essay of de Beaumont.

§ 12. The notion that all granitic veins are the result of some process of injection, and not to be confounded with concretionary veins, seems indeed to have been general up to the present time. Even von Cotta, while strongly maintaining the aqueous and concretionary origin of metalliferous veins in general, when describing those consisting of quartz, mica, feldspar, tourmaline, garnet and apatite, with cassiterite, wolfram, etc., which occur at Zinnwald and at Johanngeorgenstadt, is at a loss whether to regard these veins, from their granitic character, as igneous-fluid injections or as concretionary lodes. In support of the latter view he refers to their more or less regular and symmetrically banded structure, and while recalling the fact that mica and feldspar may both be formed in the humid way, considers the nature of these veins to be very problematical, and the question of their origin a difficult one.—(*Ore Deposits*, Prime's translation, 1870, pages 110–124).

§ 13. I have for several years taught that granitic veins of the kind just referred to are concretionary and of aqueous origin.

In 1863 I described certain veins in the crystalline schists of the Appalachian region of Canada, "where flesh-red orthoclase occurs so intermingled with chlorite and white quartz as to show the contemporaneous formation of the three species. The orthoclase generally predominates, often reposing upon or surrounded by chlorite; at other times it is imbedded in quartz, which covers the latter. Drusy cavities are also lined with small crystals of the feldspar, and have been subsequently filled with cleavable bitter-spar, sometimes associated with specular iron, rutile and sulphuretted copper ores." A study of these veins shows a transition from those "containing quartz and bitter-spar with a little chlorite or talc, through others in which feldspar gradually predominates, until we arrive at veins made up of orthoclase and quartz, sometimes including mica, and having the characters of a coarse granite; the occasional presence of sulphurets of copper and specular iron characterizing all of them alike. It is probable that these, and indeed a great proportion of quartzo-feldspathic veins are of aqueous origin, and have been deposited from solutions in fissures of the strata, precisely like metalliferous lodes. This remark applies especially to those granitic veins which include minerals containing the rarer elements. Among these are boron, phosphorus, fluorine, lithium, rubidium, glucinum, zirconium, cæsium, tin and columbium, which characterize the mineral species apatite, tourmaline, lepidolite, spodumene, beryl, zircon, allanite, cassiterite, columbite, and many others."—(*Geology of Canada*, p. 476, also p. 644.)

In this connection I referred to the occurrence of orthoclase with quartz, calcite, zeolites, epidote and native copper in certain mineral veins of Lake Superior, so well described by Prof. J. D. Whitney, (this Journal, II, xxviii, 16). The associations, according to him, show the contemporaneous crystallization of the copper, natrolite, calcite and feldspar, which last was found by analysis to be a pure potash-orthoclase.

§ 14. In 1864, this view was still farther insisted upon in this Journal, (II, xxxvii, 252), where, in speaking of mineral veinstones "which doubtless have been deposited from aqueous solution," it is added, "while their peculiar arrangement, with the predominance of quartz and non-silicated species generally serves to distinguish the contents of these veins from those of injected plutonic rocks, there are not wanting cases in which the predominance of feldspar and mica gives rise to aggregates which have a certain resemblance to dykes of intrusive granite. From these, however, true veins are generally distinguished by the presence of minerals containing boron, fluorine, phosphorus, cæsium, rubidium, lithium, glucinum, zirconium, tin, columbium, etc.; elements which are rare, or found only in minute quantities in the great mass of sediments, but are here accumulated by deposition from waters, which have removed these elements from the sedimentary rocks and deposited them subsequently in fissures."

In the Report of the Geological Survey of Canada for 1865 (p. 192), I have, in describing the veins of the Laurentian rocks, insisted still farther on the distinction just drawn between granitic dykes and granitic veinstones, which latter I have proposed to call endogenous rocks to indicate the mode of their formation, and to distinguish them from intrusive or exotic rocks, and sedimentary or indigenous rocks.

§ 15. The peculiar banded arrangement which is so characteristic in concretionary veins not granitic in composition is probably not less marked in granitic veinstones, and often appears in these in a remarkable manner, showing that they have been formed by successive depositions of mineral matter, and generally in open fissures. This structure, and various peculiarities to be observed in granitic veinstones, will be best illustrated by descriptions of various localities, most of which I have personally examined. It is proposed to notice first, the veins of the gneiss and mica-schist series of New England, and secondly those of the Laurentian rocks of New York and Canada. In the latter class will be noticed the more or less calcareous veinstones into which the Laurentian granitic veins are found to graduate.

[To be continued.]

ART. XIV.—*On Siredon Metamorphoses, etc.*; by E. D. COPE.

THE late observations by various writers on the metamorphoses of Amblystoma, especially those of Mr. Tegetmeier, indicate that some of the principal facts in the history of the subject have been overlooked by all of them.

In the first place, no one has seen any metamorphosis of true Siredon, *Siredon Mexicanus* Shaw (*S. pisciformis*, *S. axolotl* and *S. maculatus* Auctorum) which inhabits the lakes of Mexico, and of which the Smithsonian collections contain numerous specimens. Whether it undergoes a metamorphosis is entirely unknown to naturalists, though I would express the belief that it will be found to do so occasionally, under suitable circumstances. No Amblystomæ have been brought from Mexico south of Tamaulipas and Chihuahua, by any of the various naturalists collecting for the Smithsonian Institution.

In the next place, Prof. Baird was aware of the metamorphoses of all the North American species of Siredons many years before the observation of it in the Jardin des Plantes, although at first he named one of them *Siredon lichenoides* treating it as a mature animal. He regarded these creatures as larvæ in his essay on the North American Salamanders, published in Philadelphia in 1847.

Thirdly, the important observation of Duméril* established the fact that the Siredons reproduced as such, and his account, of the subsequent loss of larval characters by the offspring, is the first of a positive character which we possess on that point.

After this, in 1867,† the writer recorded the various stages of metamorphosis in different structures, to be observed in reproducing individuals of two species of *Amblystoma*, viz: *A. tigrinum* and *A. mavortium.* These embraced various Siredon characters of the dental, branchial, and dermal organs, and of coloration. It was suggested that the metamorphoses observed by Duméril were those of *A. mavortium*, which was confirmed by an examination of specimens sent to the writer by Prof. Duméril,‡ a year afterward. At the same time the periods of metamorphosis of eight other species of the genus were stated, and the Mexican *axolotl* was regarded as an *Amblystoma*, whether undergoing metamorphosis or not, owing to the irregularity of its occurrence in the most nearly allied species, *A. mavortium*, or from its Siredon stage, *S. lichenoides* Baird.

In 1868 Prof. Marsh of Yale College observed the metamorphosis of the *A. mavortium*, confirming the conclusions of previous writers. Since that time the changes have been observed by Dr. Tegetmeier and others.

The only point remaining to be determined, is whether *Siredons* (i. e. *Amblystoma Mexicanum*) undergo a metamorphosis or not. Among our numerous specimens I can find none that exhibit any tendency toward the change.

I might add here that I have had for a time in a winter fernery, a large New Jersey specimen of *Amblystoma tigrinum*, a foot in length. It is nocturnal in its habits, and remains during the day in its burrow. This extends through the long diameter of its prison, and has three outlets, which it keeps open. From one of them, as evening approaches, it projects its head, and watches with attention what is transpiring in the room.

In the same case are specimens of the common *Plethodon cinereus* of both varieties. During this, as in former years, I observe that this species is nocturnal, and is a great climber. They will climb the rachis of a most slender fern, or spear of grass, and lie in a coil on the end of a tall frond or other narrow support, which may be sufficient to bear their weight, at a height of a foot or eighteen inches above the ground. They climb a plate of glass with great ease, by adhering closely to its smooth surface with their moist abdomen. When disturbed on some high perch among the herbage, they leap away by a sudden unbending of the coiled body, in the manner of some caterpillars.

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* Bulletin Société d'Acclimatation, 1865, II, 348.
† Proceedings Acad. Nat. Sciences, Philad., 166.
‡ Origin of Genera, 1868, p. 47.

ART. XV.—*Lower Carboniferous Limestone in Ohio;* by Prof. E. B. ANDREWS.

FOR several years I have suspected that a certain limestone in southeastern Ohio should be classed with those of the Lower Carboniferous limestones. The supposition was entirely contrary to the "traditions of the elders," and furthermore, the limestone was *above* the principal range of conglomerate which has been ever regarded as true Coal-measure conglomerate. In the prosecution of the Ohio Geological Survey, in the 2d district, entrusted to me, I find that the conglomerate referred to is a Waverly conglomerate; that it is separated from the base of the productive Coal-measures by an upper Waverly sandstone group, rich in fossils, which I have called the *Logan sandstone group*, and that resting upon this group is, in many places, a limestone, called the *Maxville limestone*, which is a true Lower Carboniferous limestone. This limestone is not a continuous deposit but has only a local development here and there, always resting, however, upon the fine-grained Logan sandstone group. It was deposited in quiet basins along a uniform horizon. Generally, there is an iron ore adhering to the top of the limestone. There is no evidence that the local deposits were once continuous and united and were subsequently separated by erosion. The stratigraphical position of the limestone and the contained fossils led me to suspect that we had in it an Ohio representative of the Chester limestone of the Illinois Reports. This opinion has been confirmed. Prof. F. B. Meek, now engaged in the study of our Ohio fossils, has sent me the following report in regard to the fossils of the Maxville limestone:—

"*List of species and genera.*

1. *Zaphrentis.* A small undetermined curved conical species.
2. *Scaphiocrinus decadactylus* Hall? Described from the Chester group.
3. *Productus pileiformis* McChesney. Described from the Chester group. Thought by Mr. Davidson to be the same as *P. cora* d'Orbigny.
4. *Productus elegans* N. and P. Described from the Chester group. Some of the specimens may be the form Prof. McChesney described from the same horizon under the name *P. fasciculatus.*
5. *Chonetes.* Undetermined species.
6. *Athyris subquadrata* Hall. Described from the Chester (Kaskaskia) group.
7. *Athyris trinuclea* Hall. sp. Described from the St Louis (Warsaw) group.
8. *Spirifer* (*Martinia*) *contractus* M. and W. Described from the Chester group.
9. *Spirifer.* Undetermined fragments of perhaps two species.
10. *Terebratula.* An undetermined, small oval species showing the fine punctures under a lens.
11. *Aviculopecten.* Undetermined species.
12. *Allorisma.* Undetermined fragments, apparently like *A. antiqua* Swallow, described from the Chester group.
13. *Naticopsis.* A small undetermined species.
14. *Straparollus perspectivus* Swallow, sp. Probably a more elevated form of *S. planidorsatus* M. and W. Both were described from the Chester group.

15. *Bellerophon sublaevis* Hall. Described from the St. Louis (Warsaw) limestone.
16. *Pleurotomaria.* A small undetermined cast.
17. *Nautilus.* A small undetermined compressed, discoidal species with the very narrow periphery truncated.
18. *Nautilus.* A large sub-discoid undetermined species, with an open umbilicus and only slightly embracing volutions that are somewhat wider transversely than dorso-ventrally, and provided with a row of obscure nodes around near the middle of each side. Very nearly allied to *N. spectabilis* M. and W. from the Chester group, but more compressed and having narrower and apparently one or two more volutions. Specimens mere fragments."

In his letter Prof. Meek adds: "From these fossils, it is clearly evident that the limestone, from which they were obtained, belongs, as you had supposed, to the horizon of the Lower Carboniferous limestone series of the Western States. They also show that it does not belong to any of the inferior members of that series.

Of the 18 or 20 species of fossils sent from this rock, about one half are represented in the collection only by specimens that are too imperfect for specific identification; though none of them, so far as their characters can be made out, appear to be allied to known forms from any horizon below the St. Louis limestone.

Of the remaining species, five can be identified confidently with Chester forms, and three others are either identical with Chester species, or most closely allied to forms of that age. Hence we may safely say that eight of the species are *Chester types.* Two, however, seem to be identical with species described from the St. Louis limestone farther west.

From these facts I can scarcely doubt that we have in these local masses of limestone a representation of the Chester group of the Lower Carboniferous limestone series; though it is possible that there may also be some representation of the St. Louis limestone of the same series at some of the outcrops. * * *

The discovery of these beds is, I believe, the first indication we have had of the existence of any member of the Lower Carboniferous *limestone* series of the West in Ohio. They also seem to show that the old Carboniferous sea did not extend to this region during the deposition of any but the later members of the lower limestone series, although we know it had done so previously, that is, during the older Waverly period."

The largest and best development of the Maxville limestone is in Muskingum county, in the vicinity of Newtonville, where it is from 15 to 20 feet thick. Although here within the geographical limits of the productive coal-measures, it is well exposed in the deep valleys of Jonathan's creek and other tributaries of the Moxahala creek. It is also found in Perry, Hocking, Vinton, Jackson and Scioto counties.

A single analysis of the stone showed it to be a double carbonate of lime and magnesia.

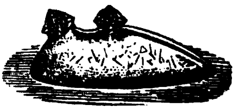
ART. XVI.—*Brief Contributions to Zoölogy from the Museum of Yale College.* No. XI. *Descriptions of some imperfectly known and new Ascidians from New England*; by A. E. VERRILL.

(Continued from page 56.)

Cynthia stellifera Verrill, sp. nov. Figures 5, 6.

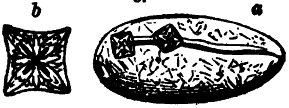
Body depressed, oval or elliptical, attached by a broad, expanded base, with thin edges. Integument firm, thick, and opaque, the surface uneven with irregular, imperfectly reticulated wrinkles, between which the surface is somewhat raised, producing an irregularly tessellated appearance, most conspicuous above; the raised parts are minutely granulous. A somewhat elevated, rounded ridge passes from the lowest end over the top and between the tubes, connecting them together. The tubes are quadrangular, low, truncate, nearly equal, a little divergent, situated toward the larger end, a little to one side, and separated by a space greater than their diameters; both have similar apertures, cross-shaped in partial expansion, and surrounded by four larger papillose lobes, between which there are many smaller ones (fig. 6, *b*).

5.



Color of the body, when living, reddish brown, ferruginous, or purplish brown, often yellowish toward the margin, the median ridge yellowish brown; apertures sometimes bright orange within, in the area immediately around the openings purplish, with minute, radiating streaks of flake-white; the four large lobes are brownish, with numerous small specks and streaks of flake-white, which often predominate over the ground-color.

6.*



The largest specimens are about an inch in length, and half an inch in breadth.

At New Haven Light and Savin Rock, near the entrance of New Haven Harbor, adhering to the under side of stones at low-water mark,—A. E. Verrill.

Cynthia monoceros.

Ascidia monoceros Möller, Index Mollusc. Groenlandiæ in Kroyer's Naturhist. Tidsskrift, iv, p. 95, 1842.

Cynthia condylomata Packard, Invert. of Lab., in Mem. Boston Soc. Nat. Hist., i, p. 277, 1867; Binney, op. cit., p. 19, Pl. xxiii, fig. 324, 1870.

An examination of Dr. Packard's original specimens shows that they are identical with Möller's species. It differs widely from all others from the American coast in the elevated tubercles of the surface and the prominent, conical summit, between the tubes.

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* Figure 6.—*Cynthia stellifera* V.; *a*, view from above, natural size; *b*, view of one of the tubes from above, enlarged about three diameters.

According to Möller the color is pale red, with red orifices.

It is an Arctic species, not yet observed south of Labrador, and the Banks of Newfoundland. From the latter locality I have seen many fine specimens, collected by T. M. Coffin and J. P. Haskell, some of them 3 inches high and ·75 in diameter.

Cynthia carnea Verrill. Figures 7, 8, 9.

Ascidia carnea Agassiz, Proc. American Assoc. for Adv. Sci., ii, p. 159, 1850, (description insufficient); Binney in Gould's Invertebrata of Mass., 2nd ed., p. 25, Pl. xxiv, figures 334, 335, 1870, (young).

? *Cynthia gutta* Stimpson, Proc. Boston Soc. Nat. Hist., iv, p. 231, 1852, (young); Binney, op. cit., p. 19, 1870.

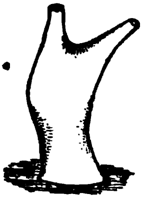
Cynthia placenta (*pars*) Packard, Mem. Boston Soc. Nat. Hist., i, p. 277, 1867; Binney, op. cit., p. 19, Pl. xxiii, figure 322, 1870; Verrill, Amer. Journ. Sci., xlix, p. 424, 1870.

When adult, this species is often two or three inches high and about an inch broad at the base, which is broadly adherent and thin at the margin.

The body is elongated, subconical, cylindrical, or urn-shaped and swollen above the middle (fig. 7), according to the state of expansion, and very changeable in form. The integument is rough, thick, firm, opaque, and reticulated with deep wrinkles, which are very conspicuous in contraction, but less numerous at the base, the interstices are raised and thickly covered with small granules. The tubes are terminal, subequal, divergent, enlarged at the bases, moderately elongated, tapering to the tips, with small square apertures. The anal tube is generally the most bent, and a little the longest. In contraction the body is low, conical, or hemispherical, with the surface coarse and rough, conspicuously reticulated and granulated; the tubes form low, four-lobed verrucæ, covered with rough granulous papillæ; the apertures are cross-shaped.

The color, when living and expanded, is dark reddish brown, or orange-brown, darker below, the wrinkles lighter than the interstices and often salmon-colored; the upper parts, especially the summit between the apertures, are deep salmon. The apertures are orange-red or salmon-color within, and surrounded by a ring of bright red. The ovaries were filled with deep red eggs and embryos, and discharged the active tadpole-shaped larvæ early in September.

7.



When younger the form is quite different (fig. 8), and when contracted corresponds in part with Packard's *C. placenta*.* In expansion, however, the central portion of the body rises up and becomes prominent, subconical, rounded at the summit, and terminated by two prominent, nearly equal tubes, which are large at the base and taper rapidly to the square apertures. The base is broadly expanded, with a thin extended margin, and adheres very closely, so that it is often impossible to detach it without rupturing the integument. The ovaries are filled with bright red eggs and embryos, nearly the color of blood. The surface is wrinkled and reticulated nearly as in the adult, except that it is not so rough; the margin of the base is nearly smooth.

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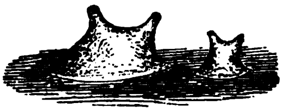
* By an examination of Dr. Packard's specimens I find that one of them belongs to a quite distinct species, having the surface minutely papillose and covered with closely adhering grains of sand.

The color is similar to that of the adult, though usually lighter; the wrinkles are generally salmon-color and the raised interstices dull reddish brown; the upper part between the tubes lighter, often salmon-color; the apertures bright red or orange inside.

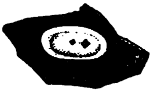
8.



When quite young (fig. 9) the body is very low and adheres by a broad base, which is very thin at the edge and expands in the form of a whitish margin around the slightly raised central part, which is oval or elliptical, and rounded above, in expansion, with the two small apertures on slightly raised tubes, one a little larger than the other. In contraction the body is nearly flat, the apertures sessile. In this state the integument is smooth at and near the margin, and only slightly roughened or indistinctly reticulated in the central parts. At a little earlier stage of growth it is entirely smooth.

The color is bright light red, deep pink-color, or blood-red, the raised interstices, when apparent, are deeper red; a bright pink or red line usually connects the two apertures, which are bright red; the thin margin of the base is whitish or light flesh-color, and transparent. The ovaries are filled, as in the older ones, with blood-red eggs and embryos. In this stage of growth it corresponds perfectly with *A. carnea* Agassiz, as figured by Binney, and probably with *A. gutta* Stimpson, though the latter may possibly be the similar young of some other species.

9.



Eastport Harbor, at extreme low-water of spring tides, under stones, rare; in 10 to 50 fathoms, on dead shells, stones, large ascidians, and *Modiola modiolus*, more common, but not abundant,—Expeditions of 1863, '64, '68, '70; South Bay, Lubec, 10 to 15 fathoms, shelly, not rare,—Exp. 1868, '70; off East Quoddy Light, young on smooth stones in 80 fathoms, abundant,—Exp. 1868; Off Head Harbor, Campo Bello I., in 100 to 120 fathoms, shelly,—Exp. 1870; Grand Menan, 15 to 20 fathoms, shelly,—Exp. 1870; Labrador, 10 to 40 fathoms,—Packard; Massachusetts Bay,—L. Agassiz, W. Stimpson.

On the European coasts there are species that have similar young, which have also received in several cases specific names. Among these *C. grossularia* Van Ben., *C. limacina* Forbes and Hanley, and the young of *C. rustica* as figured in the Zoologica Danica (Tab. xv), may be mentioned, but I am not aware of any European species corresponding to the adult state of this. *C. rustica* seems, from the figures, to be the nearest allied species, but has a contracted base, is more cylindrical or subglobular, the upper portion is more decidedly tuberculose, the apertures are farther apart and less prominent, the inner tunic is light red, yellowish below, and it is represented as attached to seaweeds by root-like processes from the base. The young are similar to those of *C. carnea*, but show no marginal expansion. The original *rustica* of Linné was an arctic species and perhaps identical with this. I adopt the name, *carnea*, in preference to the others, because it is more applicable, although when first given it was not accompanied by a recognizable description.

Cynthia echinata.

Ascidia echinata Linn., Syst. Nat., ed. xii, p. 1087, 1767, (*non* Forbes and Hanley).*

Ascidia echinata Fabr., Fauna Groenl., p. 331, 1780; Rathke, Zoologica Danica, iv, p. 10, Pl. cxxx, fig. i, 1806; Möller, Index Mollusc. Groen., in Kroyer's Nat. Tidsskrift, iv, p. 95.

Cynthia echinata Stimpson, Invert. of Grand Menan, p. 20, 1854; Binney, op. cit., p. 18, Pl. xxiii, fig. 326.

Body subglobular, attached by a small basal disk. Integument firm, opaque, more or less wrinkled, the interstices enclosed by the wrinkles raised and lighter colored, the whole surface covered with velvet-like, fine, soft fibers; with numerous scattered elevated tubercles, each bearing a stellate cluster of 6 to 9 radiating, yellowish bristles, or flexible spines. The tubes are wide apart, terminal, small, subequal, a little elevated, both with small square apertures.

The color of the body, when freed from the foreign matters which are entangled and held firmly by the spines and fibers, is usually deep salmon, often more or less tinged with pink or flesh-color, and sometimes of a delicate flesh-color throughout. The apertures are red, often bright red with a lighter red ring; the tubes frequently have eight alternate light and deep red longitudinal stripes, extending from the edge to the base of the tubes, or four light stripes extending from the angles of the apertures down their sides.

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* Two or more species have apparently been confounded under the name of *echinata*, owing to the peculiar stellate bristles with which they are covered. The *Ascidia echinata* of Forbes and Hanley (Brit. Mollusca, i, p. 35, Pl. C, fig. 4), if correctly figured, is a true *Ascidia*, very different from the present species, but covered with similar, though more distant, stellate bristles. It may be called, with propriety, *A. Forbesii*. The species described by Linnæus came from Iceland and is probably the same as that here described.

The largest specimens observed are rather more than an inch in diameter; the tubes about ·10 of an inch high, and about the same in diameter at base; the apertures about ·05.

Eastport and Grand Menan at low-water under stones; and in 10 to 120 fathoms, not uncommon, attached to other ascidians, dead shells, stones, etc.,—Expeditions of 1859, '63, '64, '58, '60; Labrador,—Packard; Greenland,—Fabricius, Lütken; Norway, —Rathke; Iceland,—Linné; Grand Banks,—T. M. Coffin.

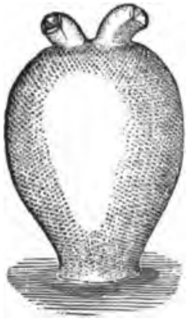
Cynthia pyriformis. Figure 10. "Sea Peach."

Ascidia pyriformis **Rathke, Zoöl. Danica, iv, p. 41, Tab. clvi, figs. 1, 2; Möller, op. cit., Kroyer's Tidss., iv, p. 95, 1842.**

Cynthia pyriformis **Stimpson, Invert. Grand Menan, p. 20, 1853; Packard, op. cit., p. 277; Binney, op. cit., p. 17, Pl. xxiii, figs. 320, 321, 1870.**

Form quite changeable, in expansion most frequently somewhat pear shaped or urn shaped, largest at or above the middle and somewhat smaller below; or subcylindrical and considerably elongated, with the top rounded; often in partial contraction subglobular, attached by a narrow base. When young the form is commonly nearly spherical, with a more or less narrowed basal attachment, and sometimes so constricted toward the base as to be slightly pedunculated. In large specimens there are usually more or less numerous, short, irregular, mostly lobed and divided rootlets, which originate close to the base. Tubes subcylindrical, large and prominent, terminal, near together at base, but divergent; the branchial one is largest and curves outward more or less abruptly; the anal is considerably smaller and swollen in the middle.

10.



Whole surface of the test minutely roughened or velvety, like the skin of a peach; it is covered with very small rounded granules or verrucæ, each of which bears a short flexible bristle or hair-like process; these, under the microscope, are found to give off minute sharp branches, directed forward, and irregularly placed; considerably larger bristles, of the same kind surround the apertures. In quite young specimens these bristles are larger and more conspicuous, being readily visible to the naked eye, and the apertures appear ciliated with the larger ones.

Color generally yellowish white, more or less tinged on the upper part and one side with peach-red; frequently yellowish white throughout, or merely tinged with orange in certain parts, especially between the tubes. Not unfrequently the color is deep orange-red or peach-red over most of the surface, except the lower part of the sides, which are flesh-color or salmon-color, and a band of light orange bordered with darker orange-red, which passes from each tube down the sides to the base; a similar band or spot generally exists between the bases of the tubes. The apertures are salmon-color inside, often surrounded by a delicate circle of red, or in the darker specimens with a pale orange circle.

The larger specimens from Eastport are often 3 inches high in expansion, and 1 to 1·25 in diameter; diameter of the branchial orifice ·25; of anal ·15 of an inch. From the Banks of New Foundland I have seen specimens 3 inches in diameter.

Massachusetts Bay,—A. E. Verrill; Eastport and Grand Manan, from near extreme low-water mark of spring tides, under and among stones, to 50 fathoms, shelly and stony, common,—Expeditions of 1859, '63, '64, '68, '70; Off Head Harbor, 80 to 120 fathoms, gravelly and shelly bottoms, common,—Exp. 1870; Grand Menan,—Stimpson; Str. Belle Isle, Labrador, —Packard; Banks of New Foundland,—C. Foster, T. M. Coffin; Greenland,—Möller, Lütken; Norway,—Rathke, Sars.

Cynthia pulchella, sp. nov.

Body subglobular, attached by a small base. Test firm, opaque, smoothish, covered with minute, flatish, slightly raised, scarcely granular elevations, visible with a lens. Tubes slightly raised, terminal, not very near together; apertures small, square, nearly equal.

Color, in alcohol, purplish or grayish white, the apertures deeper purple. The specimens were not observed while living, and were probably similar in color to *C. pyriformis*, with which they were mixed.

Diameter ·12 to ·15 of an inch, probably young.

Eastport 10 to 20 fathoms, shelly,—Exp. of 1870.

The absence of rounded verrucæ and bristles on the test will readily distinguish this species from the last, which it otherwise most resembles.

Ascidia complanata Fabr. Figure 11.

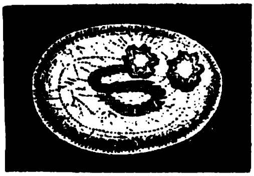
Ascidia complanata O. Fabricius, Fauna Grœnlandica, p. 332, 1780; Gmelin, Syst. Nat.

? *Ascidia orbicularis* Müller, Zool. Danica, ii, p. 53, Tab. 79, figs. 1, 2, 1788.

Ascidia callosa Stimpson, Proc. Boston Soc. Nat. Hist., iv, p. 228, 1852; Invert. Grand Manan, p. 19, 1853; Binney, op. cit., p. 26, pl. xxiii, fig. 318, 1870.

Test thick but translucent, oval or elliptical, depressed, adhering by the whole surface of the flattened left side; upper side slightly convex. In young specimens less than an inch long, the form is usually quite regular and the surface smoothish, with slight irregular wrinkles, more numerous around the tubes; in larger specimens the wrinkles become deeper, more numerous, and the surface correspondingly irregular and uneven,

11.



while the test becomes very thick and fleshy and covered with adhering worm tubes, bryozoa, hydroids, etc., and sometimes contains imbedded *Modiolariæ.* The tubes are both on the upper surface, low, sulcated, well separated, slightly divergent. The branchial tube is largest and near one end, a little to one side of the middle, often curved slightly forward, the sides with eight strong sulcations, the intervening ridges rough and often verrucose in large specimens; aperture with seven or eight lobes; each of the angles with a minute orange-red eye-spot. Anal tube smaller, low, subcylindrical, situated farther to one side, and about a third of the length from the anterior end, externally with six ribs and sulcations; aperture six-lobed, each of the angles with a minute orange eye-spot.

Color of the younger specimens pale, translucent, greenish or yellowish gray, or light horn-color, the mantle and dark intestine distinctly visible through the test; large specimens are darker greenish or olive-color, generally becoming more or less rusty brown or russet. Mantle finely speckled with raised yellowish points.

Some of the larger specimens are 4 or 5 inches long and 3 broad; ordinary ones 2 to 3 inches long, by 1 to 1·50 broad, and about ·50 high; height of tubes ·15 to ·25 of an inch; diameter ·15 to ·20.

Eastport, Me., and Grand Menan, at low-water mark under stones, in pools between tides, and at all depths to 120 fathoms, on stony bottoms, very abundant,—Expeditions of 1859, '61, '63, '64, '68, '70; Massachusetts Bay,—A. E. Verrill; Mt. Desert, Me., common,—A. E. Verrill; Labrador,—A. S. Packard; Greenland,—Fabricius, Möller; Grand Banks,—T. M. Coffin.

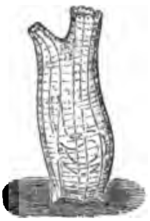
The younger specimens of this species appear to correspond perfectly with *A. complanata* of Fabricius.

Ciona tenella Verrill. Figures 12, 13.

Ascidia tenella Stimpson. Proc. Bost. Soc. Nat. Hist., iv, p. 228, 1853; Inv. of Grand Manan, p. 20, 1853; Binney, op. cit., p. 24, 1870.

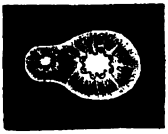
? ***Ascidia ocellata*** Ag., Proc. Amer. Assoc. for Adv. Sci., ii, p. 159, 1850 (description insufficient); Binney, op. cit., p. 24, pl. xxiv, fig. 332, 1870.

12.



Body elongated, attached by the base, soft, flaccid, varying much in shape in different states of expansion. Tubes subcylindrical, terminal, approximate, a little elongated, the anal smaller and usually divergent, in some states longer, but in other cases shorter than the branchial. Test thin, smooth, transparent; mantle with conspicuous white longitudinal lines and fine transverse ones, the intestine and branchial sac showing through distinctly. At the base the test is often prolonged into short, root-like processes for attachment. Branchial orifice with eight rounded lobes and eight light orange eye-spots; from the angles between the eyes eight conspicuous white lines pass down the sides. Anal orifice with six small lobes and six conspicuous eye-spots, like those of the branchial orifice.

13.



Color transparent whitish, with flake-white lines; mantle transparent, with whitish dendritic markings, not spotted, pale yellowish, deeper above.

The larger specimens are 3 inches long and ·75 in diameter, in expansion; more frequently the height is about 1·50, and the diameter about ·35 of an inch.

Eastport, and South Bay, Lubec, from low-water mark among stones, to 50 fathoms, stony and shelly bottoms, common,—Exp. of 1863, '64, '68, '70; off Head Harbor, 100 to 120 fathoms,—Exp. of 1868, '70; Grand Menan,—Stimpson, and Exp. of 1870; New Bedford, Mass.,—L. Agassiz.

This species is allied to *C. intestinalis* of Europe, and perhaps even more so to *C. fascicularis* Hancock, from Ireland.

ERRATA.—In the last number of this Journal, page 54, line 5, for *Molgula Manhattensis* Dekay, read *Ascidia Manhattensis* Dekay.

ART. XVII.—*On Insects inhabiting Salt Water.* No. 2. By A. S. PACKARD, Jr., M.D.

IN March, 1869, the writer published an article on this subject in the Proceedings of the Essex Institute, Salem, vol. vi, p. 41. Since then I have received an interesting collection of insects from Clear Lake, Lake Co., California, made by Prof. John Torrey, in 1865, and which he kindly placed in my hands for examination. Prof. A. E. Verrill has also allowed me to examine several puparia of Ephydra from Great Salt Lake, and during the past summer has dredged at the great depth of 20 fathoms at Eastport, Maine, a living Chironomus larva, undistinguishable from *C. oceanicus* Pack., found by me in great abundance at low-water mark in Salem harbor; and also a species of marine mite.

With the hope of awakening an interest among biologists in the subject of brine-inhabiting insects, and of receiving farther collections, especially from the salt lakes and salt works of this country, the following notes are published.

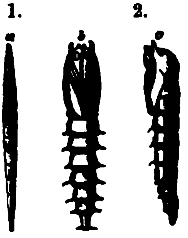
COLLECTION FROM CLEAR LAKE.

In the collection made in Clear Lake by Prof. Torrey, besides the halophilous larvæ and pupæ of Tanypus and Ephydra, were a number of bees, ichneumons, ants, and a species of Culex, the latter very abundant in the male sex, with several Muscids and Tipulæ; also a species of Chrysopa, and two species of

Coleoptera,* one a Stenus, and the other *Diabrotica soror* Lec., all of which were probably drowned from having accidentally fallen into the lake. In the collection, however, two truly aquatic beetles occurred, one, *Laccophilus decipiens* Lec., a Dytiscidan insect, and the other, *Berosus punctatissimus* Lec., a member of the family Hydrophilidæ. These probably lived in the brine not only in the adult, but also in the larval state.

Salda interstitialis Say, also occurred, and two other aquatic hemiptera: a new species of Hygrotrechus and Corixa, which are described by Mr. Uhler farther on.

Tanypus, sp.—The larvæ and pupæ of a species of Tanypus (or closely allied genus or subgenus), were abundant at Clear Lake. The body of the larva is long, slender, cylindrical, gradually tapering toward each end. The head is long and narrow, half as long as wide, and one half as long as the prothoracic segment. There are no rudiments of antennæ or maxillary palpi to be seen. In this respect it agrees with a species observed in fresh water at Salem, Mass. The mandibles are long and slender, with the ends very slender, acute, simple, untoothed, and well curved, forming two minute hooks capable of being extended a considerable distance in front of the head. The labium is broad and rounded in front, untoothed; it is situated a little in advance of the middle of the head, and is supported on a pair of slender chitinous pieces, not very approximate, with the outer ends opposite the posterior ocelli. The labrum is broad and rounded, overhanging the mouth. There are two pairs of ocelli situated a little behind the middle of the head; the anterior pair are the smaller and touch the hinder pair. A few hairs are scattered over the head. There are no prothoracic or anal feet, and no anal bristles, or appendages of any kind, not even the few long hairs observed in the Salem species. It is white and ·30 of an inch in length. Fig. 1, larva; 2, front and side view of the pupa.



Enlarged.

The pupa is rather slender, with the abdomen slightly flattened, and rather broad, being nearly as wide as the thorax. The wings and ends of the third pair of feet reach to the posterior edge of the second abdominal segment. The antennæ are laid in between the wings and the second pair of feet, disappearing under the middle of the front edge of the wing. The third pair of feet are concealed by the wings, the tips of the tarsi only being in sight; they are even with the end of the wings. The second pair of feet are entirely concealed, their tips not appearing, while the first pair are entirely in sight, their tips reaching nearly as far as those of the third pair. On the

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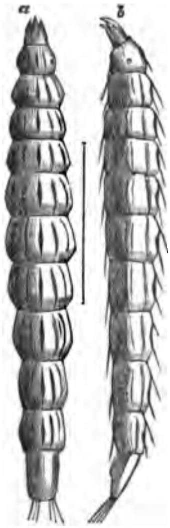
* The Coleoptera were obligingly determined by Dr. Horn.

vertex is a pair of minute, acute spines, probably locomotive. From just above the base of the head, and in front of the insertion of the wings arises a pair of meso-thoracic respiratory tubes, which are broad and flat at their base, suddenly becoming cylindrical and slender a little beyond their middle, and projecting slightly beyond the head. The mesothorax is tergally full and rounded. The abdominal segments are very convex, with the sutures deeply marked, the edges of the segments being bevelled in toward the suture. The hinder edge of each ring is raised into an acute ridge, armed with a few short hairs. The terminal segment is slender, no wider than long, and with a small acute, terminal spine on each side. No respiratory appendages. It is whitish, with a yellowish tinge, and is ·15 of an inch in length. No adult Tanapus occurred in the collection.

Stratiomys, sp. (Fig. 3 *a*, top view; *b*, side view).—With the young of Tanypus were associated several larvæ of this genus. They are long and slender, the body tapering alike toward both ends. The head is chitinous, sub-conical, and nearly as long as the prothoracic segment. On each side of the base of the head is a deep, slightly curved sinus (closed anteriorly in older specimens), thus forming a rather long tongue-like lobe to the under side of the head. Above, the head is divided by two deeply impressed lines into three lobes extending nearly to the posterior third of the head; these lobes are acutely pointed, the middle one being the longest, and embracing the clypeo-labral region. On the side of the outer lobes and at the middle of their length are situated the two ocelli. The antennæ are minute, acute tubercles situated at the ends of the outer lobes. The maxillæ (?) are two 2-jointed palpus-like appendages, with long hairs at the extremity, and play with much freedom up and down on the under side of the head, between the inner and outer lobes. Mandibles not distinguishable. The mouth parts are all inserted beyond the middle of the head. The body is rather flattened and broadest just in front of the middle; the segments are quite convex, with the sutures well marked. A pair of well marked stigmata on the prothoracic ring; none behind. The body is horn colored, paler beneath, with the integument densely punctured; the upper surface of the body is marbled with alternate light and dark streaks, in the middle of the body fading out in the middle of each segment, but toward the end of the body disappearing toward the sutures. On the side of each segment are four rows of minute dark dots, the upper row passing over the back at nearly

3.



right angles, meeting the one opposite on the median line of the body. The anal segment is broad and flat, square at the tip, but a little rounded at the corners: it is nearly as long as the greatest width of the body. From a transverse terminal slit (not seen from above) projects a group of about ten radiating respiratory filaments, white and finely ciliated to the tip, the filaments being each a little over half as long as the anal segment. A little within the middle of this segment is a rather long slit, with thickened chitinous edges. A few hairs of varying length are scattered over the body. Length ·80 of an inch. This is, so far as I am aware, the first instance of the occurrence of this genus in salt water.

Ephydra Californica, n. sp. (Fig. 4; *a*, tergal, *b*, ventral, *c*, lateral view of the pupa.)—Several specimens of the larvæ of this species occurred, though the pupæ were far more numerous. Unfortunately none of the adults were found, but as the puparia are abundant and the flies could easily be reared from them, I venture to name the species.

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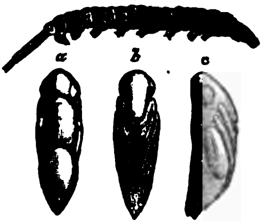

The larva closely agrees with that of the European *E. riparia* Fallen, described by Loew, but has one more pair of abdominal legs, or tubercles. The body is white, long and slender, cylindrical, the sides of the segments bulging out, and each abdominal ring has three transverse, broad, flat tergal ridges; the thoracic segments being smooth above. The anterior end of the body, including the thoracic rings, tapers gradually, being subconical and truncated abruptly. The three thoracic segments are smooth, but minutely hairy on the anterior edge, the hairs being similarly arranged on the abdominal segments. The head is very small; the mandibles exist in the form of acute, curved, chitinous hooks, with a pair of papilliform antennæ (?) behind; and a pair of shorter tubercles (rudimentary palpi ?) in front of them and just behind the mandibles.[*] The upper side of the body and base of the respiratory tubes are covered with very minute fine stiff hairs, and there is a row of them on the front edge of the prothoracic rings. On the front edge and on the sternal side of the mesothoracic ring is a dark chitinous,[†] transversely oblong area, with four clear pale dots, arranged in a transverse row, the space in front being broken up into chitinous spots; in other specimens this band is much narrower and less distinct. The integument on the tergal side

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[*] These parts need to be studied in the living insect. They are not clearly defined in alcoholic specimens. I cannot discover the spigot-like stigmata on the prothorax described by Loew.

[†] By the term "chitinous" is meant any honey-yellow portion of the integument, hardened by the deposition of chitine. This term may be used to designate this honey-yellow color, instead of the very vague word testaceous.

of the body is a little thickened and chitinous. There are eight (Loew mentions only seven in *E. salinaria*) pairs of large abdominal fleshy non-articulated legs, like the abdominal fleshy legs of lepidopterous larvæ, ending in two curvilinear rows of well curved dark brown hooks, 5 or 6 in a row; on the terminal pair of feet are four rows, those of the fourth row being minute. The respiratory tube arises suddenly from the end of the terminal segment, stretching straight out posteriorly. The main portion of the tube is rather thick, and about as long as the body is thick. It is of the same thickness throughout; the terminal branches are about one-half as long as the main portion; they also arise suddenly like the joints of a telescope, not by the subdivision of the stalk, but by the sudden prolongation of the tracheæ with their surrounding membranes, and end in a minute nipple-like conical tip, separated by a deep suture from the end of the tube. These respiratory tubes vary in length in alcoholic specimens, as they are undoubtedly more or less retractile. Length including tube, ·50 inch; length of tube, ·15 inch.

The puparium differs from that of *E. halophila* Pack., from the Illinois salt-works, in being about a third larger, and in having a large, rounded tubercle on the side of the 9th and 10th segments, and sometimes a third situated higher up on the 9th ring. The seventh pair of feet are as large as the 6th, being large and quite long, while in *E. halophila*, they are scarcely larger than the five basal pairs. While in *E. halophila* the respiratory tube is not half as long as the body, in the present species it is fully half as long. As in that species they are attached to stalks of grass by curving the anal feet around them. Length ·55 inch; length of tube ·21 inch.

The pupa is white, naked, with the vertex of the head high between the eyes. The mouth parts form a broad, flattened, thick mass, pressed to the breast and reaching the anterior coxæ. Legs folded along the abdomen, the tarsi of the first pair reaching to the distal end of the posterior coxæ; the wings reach half way between the tarsi of the first and second pair of legs; the third pair do not quite reach to the end of the abdomen. At a later stage, when the integument is more chitinous, long hairs clothe the body; the mouth parts can be distinguished, and the legs are longer, the anterior tarsi reaching to the end of the wings, and the third pair of tarsi nearly to the end of the abdomen. All the appendages are enclosed in the pupal membrane of the earlier stage. The tarsal claws are now large and of mature form, while the wing veins can be readily traced. Length, ·25 inch.

Prof. A. E. Verrill has kindly loaned me specimens of the Ephydra, from Mono Lake, Cal., "a body of water not only excessively salt, but also strongly alkaline." These belong, so far as the puparia indicate, to the above species. The puparium of *E. Californica* differs from that of *E. halophila*, in being about a third larger, and in having a large rounded tubercle on the side of the 9th and 10th segments of the body; while the seventh pair of feet are as large as the sixth, being in *E. halophila* scarcely larger than the five basal pairs. The respiratory tube is not half as long as the body in *E. halophila*. The Mono Lake specimens are ·55 inch long, and the respiratory tube ·21 inch.

Ephydra gracilis, n. sp.—These insects occur so abundantly where they are found, and can be so easily reared, that I venture to name another form from Great Salt Lake, specimens of the puparia of which have been communicated by Prof. Verrill, from the collection of Mr. Sereno Watson; and by S. A. Briggs, Esq., of Chicago. It is much smaller and slenderer than any of the preceding species, the smaller specimens being ·25 inch long, the largest ·50 inch. The respiratory tube is much longer than in any other species known to me, being in several specimens as long as the body itself; the branches into which it subdivides being over one-third as long as the base of the tube. The body is of the shape of *E. halophila*, but is much slenderer, while the feet are larger and more prominent.

Three specimens of heteropterous Hemiptera, from Clear Lake, were submitted to Mr. P. R. Uhler, who has kindly given me the following description of them.

Salda interstitialis Say. Jour. Acad. Philad., iv, p. 324.

A single ♀ specimen, from Clear Lake, California. If the specimen was taken out of the water, it had occurred there by accident. These insects do not live in the water; but affect the marshy ground sometimes adjacent to it. The specimen is immature, lacking the black color proper to the hemelytra and wings; but having the clavus, except at its tip, the base of the corium, and two or three streaks thereon black. The nervures of the membrane are simply brown.

Hygrotrechus robustus, n. sp.

One female of this genus (belonging to the family Hydrometridæ) very much mutilated, alone serves us for the present notice. In form it resembles *H. remigis* Say, but the abdomen is more uniformly robust towards the tip. The head is dark brown, fuscous on the middle, sericeous pubescent on the sides and beneath, with a pale arc on the impression at the base of the vertex. Antennæ robust, brownish-ochreous, the second joint just one-half as long as the basal one, the remaining ones destroyed. Rostrum brown, extending a very little way behind the anterior coxæ. Eyes pale brown, large. Thorax robust, pale brownish-testaceous, beneath brownish-ochreous, sericeous; the anterior lobe of pronotum blackish, divided in the middle by an ochre-yellow line, each side between the eyes adjacent to them is an abruptly elevated, rufous tubercle; the mesial carinate line feeble, becoming obliterated posteriorly; humeri elongate-tuberculate, quite prominent; pleuræ darker than the pectus. Legs robust, brownish-ochreous. Hemelytra milky-white, as long as the abdomen, the nervures brownish-ochreous. Tergum pale ochreous, brown at base, the sutures and lateral raised edge brown; connexivum with a silvery, depressed dot adjoining each suture, the apical processes robust, of medium length, hardly acute. Venter smooth, dark ochreous.

Length to tip of processes 17 millims. Breadth across humeri 3 millims.

Corixa decolor, n. sp.*

Pale testaceous, dirty amber yellow above. Form of *C. hieroglyphica* Fieber, of Europe. Head large, cranium very convex, prominent, carinate on the middle, the vertex acutely produced. Face very deeply, concavely excavated, the cavity broad oval, occupying the whole width between the eyes and extending from near the upper edge of the eyes to the base of the clypeus, the middle of the excavation densely clothed with silvery hairs. Pronotum narrower than the head, almost twice as broad as long, the middle line feebly carinated anteriorly; the surface minutely rastrated, with about eight transverse, slender brown lines, each bounded in front by a faintly impressed line, the anterior line interrupted, the posterior one following the margin of the pronotum; the posterior margin triangularly rounding, extending pretty far back. Pleural pieces whitish; sternum honey-yellow. Anterior legs short, wide, pale honey-yellow, their tibiæ broad, compressed, blade-like on the anterior margin, oblong-oval, but little longer than the palæ; palæ subtriangular, a little longer than broad, fringed with long white ciliæ; the basal angles prominent, feebly rounded, the inner edge a little concave, tip acute. Intermediate and posterior legs slender, paler than the anterior ones, ciliæ and pubescence

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* The fact that bread is made by the Mexicans from the eggs of a brine-inhabiting Corixa is noticed in Westwood's "Classification of Insects." Prof. O. C. Marsh has informed me that these brine insects are also noticed by M. Virlet d'Aoust in the Bulletin de la Société Geologique de France, 1858, xv, p. 200, and also by E. B. Tylor in his "Anahuac," London. 1861. The latter says "A favorite dish here [Tezcuco] consists of flies' eggs (*Corixa femorata* and *Notonecta unifasciata*, according to Menneville and Vielet d'Aoust) fried. These eggs are deposited at the edge of the lake, and the Indians fish them out, and sell them in the market place. So large is the quantity of these eggs that at a spot where a little stream deposits carbonate of lime, a peculiar kind of travertine is forming which consists of masses of them imbedded in the calcareous deposit."

The flies which produce these eggs are called by the Mexicans "Axayacatl" or water face. The eggs are sold in cakes in the market, pounded and cooked, and also in lumps *au naturel*, forming a substance like the roe of a fish. This is known by the characteristic name of "*ahua-uhtli*," that is, "water wheat."

In this connection we may remark that, according to the late Mr. Horace Mann, Jr., the Indians about Mono Lake eat large quantities of the puparia of *Ephydra*.

whitish. Hemelytra pale yellowish, the costal area whitish, the cross-nervule and a spot at tip brown; clavus at base with short, narrow brown lines running transversely from the outer and inner margins, beyond the middle to tip the lines run completely across; lines of the corium transverse, slender, slightly waved, many of the intermediate ones entire; membrane pale brown, with short, vermiculate, white lines. Venter and metasternum faintly dusky, the connexivum and genital segments whitish.

Length 4½ millims. Breadth across the pronotum 1½ millims. This species must be closely related to *C. Burmeisterii* Fieber, of Europe. The shape of the palæ and markings of the hemelytra of our species do not agree with Fieber's description. The specimen described is a male, which appears not to be fully mature. From Clear Lake.

MARINE INSECTS FROM DEEP WATER.

During his explorations at Eastport the past summer, Prof. Verrill dredged at the depth of 20 fathoms in Eastport harbor a larva of *Chironomus oceanicus* Pack. (Proc. Essex Inst., vol. vi, p. 42). It does not differ from specimens found by me at low-water mark in Salem harbor. It is evidently the same as the supposed larva of *Micralymma?*, mentioned and rudely figured in the American Naturalist, vol. ii, p. 278, found by me many years ago at low-water mark in Casco Bay. It is of the same size as the Salem specimens, being ·25 inch in length.

Thalassarachna Verrillii n. sp. (Fig. 5; *a*, head and mandibles and maxillary palpi; *c*, under side; *d*, anterior claw.—This

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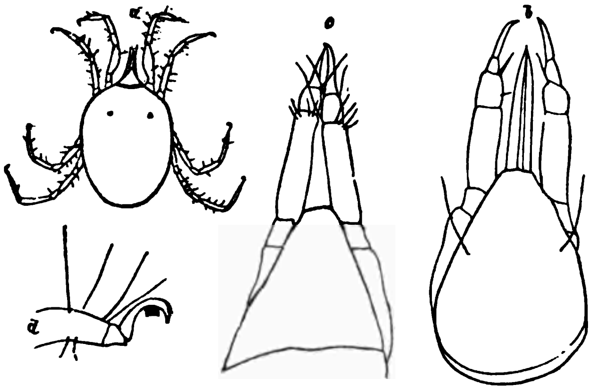

species differs in important particulars from our best known species, *Hydrachna formosa* Dana and Whelpley (Amer. Journ. Sci., xxx, 354, 1836), found near New Haven, in fresh water Unionidæ. The body of that species is much longer, the maxillary palpi are stouter and the relative length of the joints very different; the claws are very different, the forks of each claw being large and of equal size, and there is no brush on the base of the claw. At first I was disposed to place this halophilous species in the same genus as Dana and Whelpley's *Hydrachna formosa* and *H. pyriformis*, but having since then, through the kindness of Prof. Verrill, had the opportunity of studying a fresh-water mite closely allied to *H. formosa*, which is described below,* I am led to consider the salt-water mite as the type of a new genus, *Thalassarachna*, with the following differential generic characters; a conical head distinct from the rest of the body, maxillary palpi 5-jointed, each ending in an incurved spine, (the 5th joint). Mandibles large, forming an ensiform beak nearly as long as the palpi. Claws long, the upper hook minute, a single row of hairs on the under side of the lower hook, forming a brush. Otherwise closely allied to Hydrachna.

The body is globular, convex above, with the abdomen obtusely rounded behind; the skin being minutely lineated. It is blackish when alive, with the head and edge of the body white. The head is minute, conical, subacutely pointed in front. The maxillary palpi are 5-jointed, a little more than twice as long as the head, and about one-fourth as long as the fore legs. The second joint short; the third joint one-third as long as the entire palpus; the fourth as long as it is thick; the fifth minute and carrying a long, slender, slightly incurved spine bifid at the tip, the outer fork projecting considerably beyond the inner one. The mandibles form an ensiform acute beak, reaching to the middle of the terminal palpal spine. The two eyes are remote black dots situated on the anterior fourth of the body, over the insertion of the second pair of legs and just in front of them is a well marked transverse groove crossing the body. The legs are 6-jointed, much alike in structure, moderately hairy. The claws are alike in size, the hook being moderately curved, rather long, bifid at the end, the upper fork being much the smaller, especially on the anterior pairs, forming a small acute tubercle; in the middle of the under side of the claw (on all the feet) is a brush of fine hairs of equal length, arranged in a single row. On the penultimate joint of the anterior tarsi are five stout hairs; on the other tarsi three, the two proximal hairs being contiguous. External female genitalia with two bivalve contiguous plates, like those of *H. formosa* Dana and Whelpley. Length ·07 of an inch. The body of the young is whitish, longer, more ovate than in the adult; the abdomen being a little pointed behind.

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* *Hydrachna tricolor*, n. sp. Under this name I describe a beautiful mite, brought me from New Haven by Prof. Verrill after the present article was sent for publication. It is ·07 inch in length, including the palpi. It is elliptical in form, a little broader behind, being two-thirds as broad as long. Ocelli situated over the insertion of the 2d pair of legs, the distance between them equal to half the width of the body. Body orange red, middle portion of the body black-brown, due to the color of the large liver, with a Y-shaped mesial line pale straw yellow in color, formed by the interspace between the two halves of the liver; the forks of the Y clavate. Appendages very pale grass-green. Legs much as in *H. formosa*, but the hairs are longer. Maxillary palpi the same as in *H. formosa*, there being two pairs of minute spines on the 4th palpal joints. Mouth and lancet-formed organ (languette) protruded as in *H. formosa*. "Bifid linguette" at the base of maxillary palpi, as in *H. formosa*. The rudimentary mandibles form a conical protuberance, the base situated within the body, each mandible being twice as long as broad, and reaching to the basal third of the 2d maxillary joint.

Twelve eggs, ten of them fully formed, being as long as the basal joints of the legs, could be seen on the under side of the body. The mite was alive Dec. 30, showing that the eggs, probably laid in the spring, are formed in the preceding autumn.

With the exception of Philippi's *Pontarachna punctulatum* (Wiegmann's Archiv, vol. vi, p. 191, 1840, Pl. iv, fig. 4, 5), which was discovered by him in the bay of Naples (he does not state at what depth, consequently I infer that it was in shallow water), the species under consideration is the only one which, so far as I am aware, has been found to be exclusively marine. The genus Pontarachna is very different from Hydrachna and Thalassarachna, and I should judge that it rather approaches Atax. It differs from Thalassarachna in the shorter, unarmed palpi, and in the apparent (Philippi does not mention or figure them) absence of a mandibular beak. The palpi are half as long as the fore legs.

The present species was dredged by Prof. Verrill in 20 fathoms, on Clark's Ledge, in Eastport Harbor. It was found (four or five specimens, young and adult), "on hydroids," &c. It will be an interesting point to determine whether, like the other species of the genus, it also lives in the earlier, or even in the adult state among the gills of Lamellibranchs, and also whether it lives between tide marks, thus agreeing with the distribution of *Chironomous oceanicus.* At any rate we have here an insect and a mite breathing by tracheæ, and extracting the oxygen from the water at the great depth of 120 feet, and, in the case of the dipterous larva, with no apparent variation from specimens living at low-water mark. In this connection I might notice the fact that we have on our New England and Labrador shores several species of mites of the family Trombididæ, which run over seaweeds and live under stones between tide marks, and I have observed similar species at Beaufort, N. C., and Key West, Florida.

As regards the distribution of the species of brine insects, several questions of interest arise. How are we to account for the origin of the *Ephydra halophila* in such prodigious quantities in the vats of the Equality Salt Works of Illinois, a locality remote from salt lakes and the ocean shores? Are the brine species of the Salt Lakes of Utah and California, remnants of an oceanic fauna, and of the tertiary period, or are they of recent and local origin? Have these brine insects acquired their singular tastes within a recent geological period (say the Quaternary), having lived at first as do their allied species, in foul fresh water, or amid decaying matter in damp localities? Before these and other questions can be answered, we must have analyses of the waters, and a review of the European literature of the subject,* and larger collections of brine animals from our own country.

Peabody Academy of Science, Salem, Nov. 16, 1870.

ART. XVIII.—*On the existence of the Nummulitic formation in China;* by Baron VON RICHTHOFEN. (From a letter to Prof. J. D. WHITNEY, dated Su-Chan, China, Dec. 12th, 1868).

THE subject of this letter is the discovery of the *occurrence of the Nummulitic formation in China*, a fact which adds one more to the short series of formations known, chiefly by the labors of Mr. Pumpelly, to enter into the composition of this country.

Mr. Pumpelly cites, on the strength of a statement by Rev. Mr. Edkins, the island of Si-Tung-ting in Tai-hu lake (a sheet of water of about eight hundred square miles, sixty miles west of Shanghai), as a fossiliferous locality. As he learned that the fossils were found in limestone, he was naturally led to the conclusion that this rock formed part of the wide-spread Devonian limestone. Inquiries which I made in Shanghai confirmed the fact of the occurrence of fossils. There, too, they were considered as Devonian, and I was advised by a really skillful geologist, to study their mode of occurrence, as this would give me the clue for the structure of most portions of

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* I am indebted to Mr. F. Walker of London for the following note on the habits of the English species of Ephydra and its allies. He writes under date of Dec. 6, 1870. "I have observed species of Ephydra along the sea shore as well as several inland aquatic species. I am indebted to my friend, the late A. H. Haliday, for the descriptions of the species of this and the neighboring genera in my Diptera Britannica, vol. 2. I am not aware that the species are very different in their habits, and he does not mention them as such. He writes of the following species as occurring on the sea shore.

Heccameda albicans, on sandy coasts, especially on fresh rejectamenta.
Hydrellia thoracica, on the sea coast.
Atissa pygmæa, in a salt marsh.
Glenanthe ripicola, muddy sea coast.
Scatella sibillans, sea coast.
" *leucostoma*, marine rejectamenta.
" *æstuans*, among fuci.
" *despecta*, sea coast and sandy places.

Teichomyza fusca, on chalk cliffs a little above high water mark; swarms also occur in urinatories in London and other towns. Von Heydeu, in the Entomologische Zeitung, Stettin, mentions *Cœnia halophila* as a sea-side insect. I believe that no European Stratiomys has been discovered to live as a larva in sea brine."

China, in particular to the mode of occurrence of the Devonian limestone.

I consequently visited the place a few days ago, on a journey overland from Ningpo to Ching-kiang. As no limestone of more recent age than the Devonian was heretofore known in China, I was much surprised to meet with nummulites almost at first sight, and afterward I found the rock in places nearly made up of them. The rock is well exposed to view by enormous quarries, which appeared to have been worked for an immensely long time. The weathered surface of those fragments covering the more ancient waste-dumps shows the structure of the shells with remarkable distinctness, even the minute pores being clearly recognizable with a glass, so that there can not be the least doubt in regard to the true character of the fossil. Several species of Nummulina appear to be represented, as is indicated by the differences in shape of the cross-sections.

As Nummulites are characteristic only of one distinct part of the Eocene period, the fact of their occurrence should be sufficient evidence for the determination of the age of any rocks in which they are met with. But I found myself now in face of the strange fact, that it was partly on the strength of its fossils that the limestone in question had heretofore been considered as Devonian. I attempted therefore to collect its fauna more fully. I found the rock in places full of fossils, mostly bivalves and gasteropods, which have by no means a Paleozoic appearance. They are in an excellent state of preservation, the shells being only bleached. But the limestone is so hard and brittle that I destroyed nearly every specimen which I tried to save; yet I succeeded in getting a few good ones of bivalves. The forms of these fossils, as well as their state of preservation, reminded me much of similar occurrences in the Nummulitic limestone of Dalmatia. Besides gasteropods and bivalves, there occur corals and fragments of very large encrinites. Some of the former which I collected can probably be determined. But I failed to discover a single brachiopod, which are almost the only fossils supposed to be characteristic of the Devonian limestone of China. I presume that indistinct fragments of bivalves, which are usually all that can be obtained, have given rise to the belief of the occurrence of brachiopods on the Si-Tung-ting. Perhaps, too, real brachiopods may have been derived from other places in or near Tai-hu lake, as it is quite possible that true Devonian limestone may occur in the neighborhood.

The nummulitic limestone of Si-Tung-ting is very bituminous. It is burnt in kilns and emits a remarkably strong smell. Its thickness cannot be accurately determined, but it is certainly not more than six hundred feet. Its beds are nearly horizontal, and rest on ancient sandstones, the strata of which are inclined at an angle of about twenty degrees. These sandstones are supposed by Mr. Kingsmill to have a thickness of about ten thousand feet.

Before visiting Si-Tung-ting, I had observed the occurrence of limestone in the neighborhood of the sea coast, near Hang-chau in the province of Che-Kiang, a place mentioned in Mr. Pumpelly's list of localities distinguished by the occurrence of useful minerals. As it rests there quite unconformably on sandstone similar to that which underlies it at Tung-ting, and has a similar lithological character, I believe that I may safely refer it to the same formation with that of Tung-ting. I shall hence look out for its further distribution in China. The subject is not without some practical interest, in a country where all limestone was assumed to underlie the coal and iron-bearing formations.

In 1861, the easternmost place where the Nummulitic formation was known to occur was northern India. I succeeded in that year in proving its existence so far east as Japan and the Philippines, a notice of which you may find in a paper published in the Jahrbuch der deutschen geologischen Gesellschaft of 1861 or 1862. I do not know whether the same formation has since then been found in the regions intermediate between those two countries and India. The occurrence in lake Tai-hu is one of the connecting links, and it is now quite likely that this interesting formation, occurring in places so far apart, is among the most widely distributed in Eastern Asia; and it is quite possible that one unbroken area of submergence may be proved to have extended during the short existence of the genus Nummulina, from Spain to the Philippines and Japan.

I may add, as a sort of voucher for the correctness of my observation, that its communication places me into the disagreeable position of taking opposite views from those of Mr. Kingsmill, a gentleman who has, besides his professional activity as architect in Shanghai, worked of late years with admirable success in the geology of some parts of China. He informed me, some time before I visited Tung-ting, that he had sent a paper on the geology of that locality to the London Geological Society, in the Journal of which it may be printed by this time. The views which he informed me he had taken therein are, that the limestone of Tung-ting is Devonian or Subcarboniferous, and that the great sandstone formation, which plays a very important part in the geology of Eastern China, preceded it in age. The relations observed at Si-Tung-ting do no longer justify this conclusion, after the discovery of the nummulites, and the age of the sandstone (Tung-ting-grits of Mr. Kingsmill) must therefore be considered as not yet safely established. Mr. Kingsmill has, however, succeeded in collecting some remains of plants in the upper layers of the sandstone, and it is to be hoped that they will suffice to determine its age. The state of the weather prevented me from hunting for the locality where he found them.

ART. XIX.—*Note on the Infusoria Flagellata and the Spongiæ Ciliatæ;* by Prof. H. JAMES-CLARK, Kentucky University, Lexington, Ky.

I send this note in hopes that it may be of interest to those readers of this Journal who have followed the recent discussions upon spontaneous generation and the doctrine of evolution. It is an effort to clear up the chaos of uncertainty which has reigned among the lower Protozoa for years past, and particularly in the heterogeneous group of so-called Sponges. The aim of the Evolutionists is clearly, by refusing to recognize their truly organized structure, to depress these creatures to such a low level in grade, that they shall appear but a step above the lifeless protoplasm which some think has been seen *almost* manufactured in the laboratory of the chemist. After hypothetically developing "organizable protoplasm" out of "inferior types of organic substances," which in the process, *per se*, under "the mutual influences" of its metamorphic forms, generates still more *sensitive* organic matter, until it finally attains to the possession of *vital* actions, the evolutionist imagines himself able "deductively to bridge the interval" between the so-called "nascent life" and the unmistakable vitalism of the slimy Rhizopod (see Herbert Spencer, Appleton's Journal, Aug. 7th 1869, p. 598.)

My own researches have constantly tended in the opposite direction. In spite of the apparent physical simplicity of even the lowest of the Protozoa (Amœba and the like), their habits and the phenomena attendant upon their mode of locomotion, their determinate prehensile acts, so wonderfully like consciousness of an end to be accomplished, and their undeniably specialized digestive functions, all lead to the conclusion, which with me is a fact, that they possess a degree of differentiation in *esse* as marked as that which we recognize as *potential* in the earliest stage of the vertebrate embryo. In the former, the organization is present, but not circumscribed into regions; in the latter it is also present uncircumscribed, but it is to be eventually differentiated. The Sponges, with their supposed slimy, protoplasm-like simplicity, have been in former years the hunting ground of the developmentalists, but of late, that group has been slipping out from under the feet of those philosophers.

Carter first detected the true *criterion* of their animality, though erring as to their classificatory relationship. It was my good fortune to prove their close alliance with the *Flagellata*, in a memoir (Mem. Boston Soc. Nat. Hist., vol. i, pt. III, Sept. 1867, *On the Spongiæ Ciliatæ as Infusoria Flagellata*), published some few years ago. I described certain monad-like infusoria which possessed a single *flagellum* surrounded by a projecting membranous collar. Some forms were appended to branching stems (*Codosiga*) and others were ensheathed in a funnel-shaped or urnæform tube (*Salpingœca*). The monadiform body of these I showed to be identical with the ciliate bodies of one of the *Spongiæ Ciliatæ* (*Leucosolenia*), and homologised the branching stem and the ensheathing tubes of the former with the gelatinous mass of the latter, into which its monads were imbedded. The connection seemed not even a step wide, so clear and unmistakable was the relationship. That there should ever be discovered a form which would lie so intermediate between these as to make me hesitate whether it belonged to the one or the other, I did not even hope for; but it has come unexpectedly. In Schultzes Archiv. für Mikroskopische Anatomie, (Bd. VI, 4, 1870), Cienkowsky describes, under the name *Phalansterium*, a genus which consists of monad-like bodies with a *flagellum* and a projecting collar like those of *Codosiga*, *Salpingœca* and *Leucosolenia*. Of the two species which he illustrates, one (*P. consociatum*) has monads enveloped in a broad funnel-shaped, slimy sheath, and these sheaths are closely packed side by side, radiatingly, so as to form a shield-like or a hemispherical mass. This comes nearest to the *Salpingœca*. The other species (*P. intestinum*) possesses similar monads, but they are imbedded basally in a gelatinous, intestiniform mass of slime (*Schleim*) " with their vibrating lashes extending in every direction " about the cylindrical colony. Originally each monad is endowed with a separate slime-sheath; but eventually these all are fused together into one common mass. Beyond this, to make a true Sponge we need but the presence of spiculæ, and open interspaces in the slimy mass, between the monads, leading to one common cavity. Introvert the layer of monads and we produce the desired effect without doing violence to their relative positions. It is a mere matter of proportions, just as the inverted cyathiform rose-hip is none the less an ovariferous disc than the globular receptacle of the strawberry.

ART. XX.—*Memoir of Thomas Graham;* by Prof. JOSIAH P. COOKE, Jr.*

IT would be difficult to find in the history of science a character more simple, more noble, or more symmetrical in all its parts than that of THOMAS GRAHAM, and he will always be remembered as one of the most eminent of those great students of nature, who have rendered our Saxon race illustrious. He was born of Scotch parents in Glasgow in the year 1805, and in that city, where he received his education, all his early life was passed. In 1837 he went to London as Professor of Chemistry in the newly established London University now called University College, and he occupied this chair until the year 1855, when he succeeded Sir John Herschel as Master of the Royal Mint, a post which he held to the close of his life. His death, on the 16th of September last, at the age of sixty, though occasioned by a severe cold, was really the wearing out of a constitution enfeebled in youth by excessive labor, voluntarily undertaken and courageously borne, that he might devote his life to scientific study. As with all earnest students, that life was uneventful, if judged by ordinary standards; and the records of his discoveries form the only materials for his biography. Although one of the most successful investigators of Physical Science, the late Master of the Mint had not that felicity of language or that copiousness of illustration, which added so much to the popular reputation of his distinguished contemporary, Faraday; but his influence on the progress of science was not less marked or less important. Both of these eminent men were for a long period of years best known to the English public as teachers of Chemistry, but their investigations were chiefly limited to physical problems; yet, although both cultivated the border ground between Chemistry and Physics, they followed wholly different lines of research. While Faraday was so successfully developing the principles of electrical action, Graham with equal success was investigating the laws of molecular motion. Each followed with wonderful constancy, as well as skill, a single line of study from first to last, and to this concentration of power their great discoveries are largely due.

One of the earliest and most important of Graham's investigations, and the one which gave the direction to his subsequent course of study, was that on the diffusion of gases. It had already been recognized that impenetrability in its ordinary sense is not, as was formerly supposed, a universal quality of matter. Dalton had not only recognized that aëriform bodies exhibit a positive tendency to mix, or to penetrate through each other, even in opposition to the force of gravity, but had made this quality of gases the subject of experimental investigation. He inferred, as the result of his inquiry, "that different gases afford no resistance to each other; but that one gas spreads or expands into the space occupied by another gas, as it would rush into a vacuum; at least, that the resistance which the particles of one gas offer to those of another is of a very imperfect kind, to be compared to the resistance which stones in the channel of a stream oppose to the flow of running water." But although this theory of Dalton was essentially correct and involved the whole truth, yet it was supported by no sufficient evidence, and he failed to perceive the simple law which underlies this whole class of phenomena.

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* From the Proceedings of the American Academy of Arts and Sciences, vol. viii, May 24, 1870.

Graham, "on entering on this inquiry, found that gases diffuse into the atmosphere with different degrees of ease and rapidity." This was first observed by allowing each gas to diffuse from a bottle into the air through a narrow tube in opposition to the solicitation of gravity. Afterwards an observation of Doebereiner on the escape of hydrogen gas by a fissure or crack in a glass receiver caused him to vary the conditions of his experiments, and led to the invention of the well known "Diffusion Tube." In this simple apparatus a thin septum of plaster of Paris is used to separate the diffusing gases, which, while it arrests in a great measure all direct currents between the two media, does not interfere with the molecular motion. Much later, Graham found in prepared graphite a material far better adapted to this purpose than the plaster, and he used septa of this mineral to confirm his early results, in answer to certain ill-considered criticisms in Bunsen's work on Gasometry. These septa he was in the habit of calling his "atomic filters." By means of the diffusion tube Graham was able to measure accurately the relative times of diffusion of different gases, and he found that *equal volumes of any two gases interpenetrate each other in times which are inversely proportional to the square roots of their respective densities*, and this fundamental law was the greatest discovery of our late foreign associate. It is now universally recognized as one of the few great cardinal principles which form the basis of physical science.

It can be shown, on the principles of pneumatics, that gases should rush into a vacuum with velocities corresponding to the numbers which have been found to express their diffusion times; and, in a series of experiments on what he calls the "*Effusion*" of gases, Graham confirmed by trial this deduction of theory. In these experiments a measured volume of the gas was allowed to find its way into the vacuous jar through a minute aperture in a thin metallic plate, and he carefully distinguished between this class of phenomena and the flowing of gases through capillary tubes into a vacuum, in which case, however short the tube, the effects of friction materially modify the result. This last class of phenomena Graham likewise investigated, and designated by the term "Transpiration."

While, however, it thus appears that the results of Graham's investigation were in strict accordance with Dalton's theory, it must also be evident that Graham was the first to observe the exact numerical relation which obtains in this class of phenomena, and that all-important circumstance entitles him to be regarded as the discoverer of the law of Diffusion. The law, however, as first enunciated, was purely empirical, and Graham himself says that something more must be assumed than that gases are vacua to each other, in order to explain all the phenomena observed; and according to his original view this representation of the process was only a convenient mode of expressing the final result. Such has proved to be the case.

Like other great men, Graham built better than he knew. In the progress of physical science during the last twenty-five years, two principles have become more and more conspicuous, until at last they have completely revolutionized the philosophy of Chemistry. In the first place it has appeared that a host of chemical as well as of physical facts are coördinated by the assumption that all substances in the state of gas have the same molecular volume, or, in other words, contain the same number of molecules in a given space; and in the second place, it has become evident that the phenomena of heat are simply the manifestations of molecular motion. According to this view, the temperature of a body is the *vis viva* of its molecules; and, since all molecules at a given temperature have the same *vis viva*, it follows that the molecules must move with velocities which are inversely proportional to the square roots of the molecular weights. Moreover, since the molecular volumes are equal, and the molecular weights therefore proportional to the densities of the aëriform bodies in which the molecules are the active units, it also follows that the velocities of the molecules in any two gases are inversely proportional to the square roots of their respective densities. Thus the simple numerical relations first observed in the phenomena of diffusion are the direct result of molecular motion, and it is now seen that Graham's empirical law is included under the fundamental laws of motion. His investigation has become the basis of the new science of molecular mechanics, and his measurements of the rates of diffusion prove to be the measures of molecular velocities.

From the study of diffusion, Graham passed by a natural transition to the investigation of a class of phenomena, which, although closely allied to the first, as to the effects produced, differ wholly in their essential nature. Here also he followed in the footsteps of Dalton. This distinguished chemist had noticed that a bubble of air separated by a film of water from an atmosphere of carbonic anhydride, gradually expanded until it burst. In like manner a moist bladder, half filled with air, and tied, if suspended in an atmosphere of the same material, becomes in time greatly distended by the insinuation of this gas through its substance. This effect cannot be the result of simple diffusion; for it is to be remembered that the thinnest film of water, or of any liquid, is absolutely impermeable to a gas as such; and, moreover, only the carbonic anhydride passes through the film, very little or none of the air escaping outward. The result depends, first, upon the solution of the carbonic anhydride by the water on one surface of the film; secondly, on the evaporation into the air, from the other surface, of the gas thus absorbed. Similar experiments were made by Drs. Mitchell and Faust, and others, in which gases passed through a film of india-rubber, entering into a partial combination with the material on one surface, and escaping from it on the other.

Graham not only considerably extended our knowledge of this class of phenomena, but also gave us a satisfactory explanation of the mode in which these remarkable results are produced. He recognized in these cases the action of a feeble chemical force, insufficient to produce a definite compound, but still capable of determining a more or less perfect union, as in the case of simple solution. He also distinguished the influence of mass in causing the formation or decomposition of such weak chemical compounds. The conditions of the phenomena under consideration are simply these:—

First. A material for the septum capable of forming a feeble chemical union with the gas to be transferred.

Secondly. An excess of the gas on one side of the film and a deficiency on the other.

Thirdly. Such a temperature that the unstable compound may form at the surface, where the aëriform constituent is present in large mass, while it decomposes at the opposite surface, where the quantity is less abundant.

One of the most remarkable results of Graham's study of this peculiar mode of transfer of aëriform matter through the very substance of solid bodies was an ingenious method of separating the oxygen from the atmosphere. The apparatus consisted simply of a bag of india-rubber, kept distended by an interior framework, while it was exhausted by a Sprengel pump. Under these circumstances the selective affinity of the caoutchouc determines such a difference in the rate of transfer of the two constituents of the atmosphere that the amount of oxygen in the transpired air rises to forty per cent, and by repeating the process nearly pure oxygen may be obtained. It was at first hoped that this method might find a valuable application in the arts, but in this Graham was disappointed; for the same result has since been effected by purely chemical methods, which are both cheaper and more rapid.

These experiments on india-rubber naturally led to the study of similar effects produced with metallic septa, which, although to some extent previously observed in passing gases through heated metallic tubes, had been only imperfectly understood. Thus, when a stream of hydrogen or carbonic oxide is passed through a red-hot iron tube, a no inconsiderable portion of the gas escapes through the walls. The same is true to a still greater degree when hydrogen is passed through a red-hot tube of platinum, and Graham showed that through the walls of a tube of palladium hydrogen gas passes, under the same conditions, almost as rapidly as water through a sieve. Moreover, our distinguished associate proved that this rapid transfer of gas through these dense metallic septa was due, as in the case of the india-rubber, to an actual chemical combination of its material with the metal, formed at the surface, where the gas is in excess, and as rapidly decomposed on the opposite face of the septum. He not only recognized as belonging to this class of phenomena the very great absorption of hydrogen by platinum plate and sponge in the familiar experiment of the Doebereiner lamp, but also showed that this gas is, in some cases at least, a definite constituent of meteoric iron,—a fact of great interest from its bearing on the meteoric theory.

We are thus led to Graham's last important discovery, which was the justification of the theory we have been considering, and the crowning of this long line of investigation. As may be anticipated from what has been said, the most marked example of that order of chemical compounds, to which the metallic transpiration of aëriform matter we have been considering is due, is the compound of palladium with hydrogen. Graham showed that when a plate of this metal is made the negative pole in the electrolysis of water, it absorbs nearly one thousand times its volume of hydrogen gas,—a quantity approximately equivalent to one atom of hydrogen to each atom of palladium. He further showed that the metal thus becomes so profoundly altered as to indicate that the product of this union is a definite compound. Not only is the volume of the metal increased, but its tenacity and conducting power for electricity are diminished, and it acquires a slight susceptibility to magnetism, which the pure metal does not possess. The chemical qualities of this product are also remarkable. It precipitates mercury from a solution of its chloride, and in general acts as a strong reducing agent. Exposed to the action of chlorine, bromine, or iodine, the hydrogen leaves the palladium and enters into direct union with these elements. Moreover, although the compound is readily decomposed by heat, the gas cannot be expelled from the metal by simple mechanical means.

These facts recall the similar relations frequently observed between the qualities of an alloy and those of the constituent metals, and suggest the inference made by Graham, that palladium charged with hydrogen is a compound of the same class, —a conclusion which harmonizes with the theory long held by many chemists, that hydrogen gas is the vapor of a very volatile metal. This element, however, when combined with palladium, is in a peculiarly active state, which sustains somewhat the same relation to the familiar gas that ozone bears to ordinary oxygen. Hence Graham distinguished this condition of hydrogen by the term "Hydrogenium." Shortly before his death a medal was struck at the Royal Mint from the hydrogen palladium alloy in honor of its discovery; but although this discovery attracted public attention chiefly on account of the singular chemical relations of hydrogen, which it brought so prominently to notice, it will be remembered in the history of science rather as the beautiful termination of a life-long investigation, of which the medal was the appropriate seal.

Simultaneously with the experiments on *gases*, whose results we have endeavored to present in the preceding pages, Graham carried forward a parallel line of investigation of an allied class of phenomena, which may be regarded as the manifestations of molecular motion in *liquid* bodies. The phenomena of diffusion reappear in liquids, and Graham carefully observed the times in which equal weights of various salts dissolved in water diffused from an open-mouth bottle into a large volume of pure water, in which the bottle was immersed. He was not, however, able to correlate the results of these experiments by such a simple law as that which obtains with gases. It appeared, nevertheless, that the rate of diffusion differs very greatly for the different soluble salts, having some relation to the chemical composition of the salt which he was unable to discover. But he found it possible to divide the salts into groups of equi-diffusive substances, and he showed that the rates of diffusion of the several groups bear to one another simple numerical ratios.

More important results were obtained from the study of a class of phenomena corresponding to the transpiration of gases through india-rubber or metallic septa. These phenomena, as manifested in the transfer of liquids and of salts in solution through bladder, or a similar membrane, had previously been frequently studied under the names of exosmose and endosmose, but to Graham we owe the first satisfactory explanation. As in the case of gases, he referred these effects to the influence of chemical force, combination taking place on one surface of the membrane, and the compound breaking up on the other, the difference depending, as in the previous instance, on the influence of mass. He also swept away the arbitrary distinctions made by previous experimenters, showed that this whole class of phenomena are essentially similar, and called this manifestation of power simply "osmose."

While studying osmotic action, Graham was led to one of his most important generalizations,—the recognition of the crystalline and amorphous states as fundamental distinctions in chemistry. Bodies in the first state he calls crystalloids; those in the last state, colloids (resembling glue). That there is a difference in structure between crystalloids, like sugar or feldspar, and colloids, like barley candy or glass, has of course always been evident to the most superficial observer; but Graham was the first to recognize in these external differences two fundamentally distinct conditions of matter not peculiar to certain substances, but underlying all chemical differences, and appearing to a greater or less degree in every substance. He showed that the power of diffusion through liquids depends very much on these fundamental differences of condition,—sugar, one of the least diffusible of the crystalloids, diffusing fourteen times more rapidly than caromel, the corresponding colloid. He also showed that, in accordance with the general chemical rule, while colloids readily combine with crystalloids, bodies in the same condition manifest little or no tendency to chemical union. Hence in osmose, where the membranes employed are invariably colloidal, the osmotic action is confined almost entirely to crystalloids, since they alone are capable of entering into that combination with the material of the septum on which the whole action depends.

On the above principles Graham based a simple method of separating crystalloids from colloids, which he called "dialysis," and which was a most valuable addition to the means of chemical analysis. A shallow tray, prepared by stretching parchment paper (an insoluble colloid) over a gutta-percha hoop, is the only apparatus required. The solution to be "dialyzed" is poured into this tray, which is then floated on pure water, whose volume should be eight or ten times greater than that of the solution. Under these conditions the crystalloids will diffuse through the porous septum into the water, leaving the colloids on the tray, and in the course of a few days a more or less complete separation of the two classes of bodies will have taken place. In this way arsenious acid and similar crystalloids may be separated from the colloidal materials with which, in the case of poisoning, they are usually found mixed in the animal juices or tissues.

But besides having these practical applications, the method of dialysis in the hands of Graham yielded the most startling results, developing an almost entirely new class of bodies as the colloidal forms of our most familiar substances, and justifying the conclusion that the colloidal as well as the crystalline condition is an almost universal attribute of matter. Thus, he was able to obtain solutions in water of the colloidal states of aluminic, ferric, chromic, stannic, metastannic, titannic, molybdic, tungstic, and silicic hydrates, all of which gelatinize under definite conditions like a solution of glue. The wonderful nature of these facts can be thoroughly appreciated only by those familiar with the subject, but all may understand the surprise with which the chemist saw such hard, insoluble bodies as flint dissolved abundantly in water and converted into soft jellies. These facts are, without doubt, the most important contributions of Dr. Graham to pure chemistry.

In this sketch of the scientific career of our late Associate, we have followed the logical, rather than the chronological, order of events, hoping thus to render the relations of the different parts of his work more intelligible. It must be remembered, however, that the two lines of investigation we have distinguished were in fact interwoven, and that the beautiful harmony which his completed life presents was the result, not of a preconceived plan but of a constant devotion to truth, and a child-like faith, which unhesitatingly pressed forward whenever nature pointed out the way.

Although the investigations of the phenomena connected with the molecular motion in gases and liquids were by far the most important of Dr. Graham's labors, he also contributed to chemistry many researches which cannot be included under this head. Of these, which we may regard as his detached efforts, the most important was his investigation of the hydrates and other salts of phosphorus. It is true that the interpretation he gave of the results has been materially modified by the modern chemical philosophy, yet the facts which he established form an important part of the basis on which that philosophy rests. Indeed, it seems as if he almost anticipated the later doctrines of types and polybasic acids, and in none of his work did he show more discriminating observation or acute reasoning. A subsequent investigation on the condition of water in several crystalline salts and in the hydrates of sulphuric acid is equally remarkable. Lastly, Graham also made interesting observations on the combination of alcohol with salts, on the process of etherification, on the slow oxidation of phosphorous, and on the spontaneous inflammability of phosphuretted hydrogen. It would not, however, be appropriate in this place to do more than enumerate the subjects of these less important studies; and we have only aimed in this sketch to give a general view of the character of the field which this eminent student of nature chiefly cultivated, and to show how abundant was the harvest of truth which we owe to his faithful toil.

Graham was not a voluminous writer. His scientific papers were all very brief, but comprehensive, and his "Elements of Chemistry" was his only large work. This was an admirable exposition of chemical physics, as well as of pure chemistry, and gave a more philosophical account of the theory of the galvanic battery than had previously appeared. Our late associate was fortunate in receiving during life a generous recognition of the value of his labors. His membership was sought by almost all the chief scientific societies of the world, and he enjoyed to a high degree the confidence and esteem of his associates. Indeed, he was singularly elevated above the petty jealousies and belittling quarrels, which so often mar the beauty of a student's life, while the great loveliness and kindliness of his nature closely endeared him to his friends. He was never married, keeping house with a sister at No. 4 Gordon Square, where he dispensed a liberal hospitality, which has been enjoyed by many of our scientific countrymen who have visited London during the last twenty years.

In concluding, we must not forget to mention that most genial trait of Graham's character, his sympathy with young men, which gave him great influence as a teacher in the College with which he was long associated. There are many now prominent in the scientific world who have found in his encouragement the strongest incentive to perseverance, and in his approval and friendship the best reward of success.

ART. XXI.—*Note on transversely striated muscular fiber among the Gasteropoda;* by W. H. DALL.

IN studying the radula of a species of *Acmæa* (probably *A. Borneënsis* Rve), obtained by Prof. A. S. Bickmore at Amboyna, I noticed, on placing the structure under a power of 100 diameters, that certain of the muscular fibers which adhered to it, when torn from the buccal mass, had a different appearance from the others. On increasing the power to some 800 diameters, it was at once evident that the different aspect of these fasciculi was caused by fine, but clearly defined, transverse striation. Suspecting that it was an optical delusion, caused by a very regular arrangement of the nuclei of the fibres, I subjected the muscle to various tests and to still higher magnifying powers. I also introduced under the same glass, some of the voluntary dorsal muscles of a small crustacean, for comparison. The structure of the ultimate fibers in both appeared to be similar. These seemed to be composed of a homogeneous tube or cylindrical band of translucent matter, with nuclei interspersed at irregular intervals. In neither was there any appearance of separation into transverse disks, as is seen in the striated muscles of vertebrates. That the striated appearance was not due to contraction and folding of the muscle, was evident upon taking a side view of one of the fibers, when the striæ on each side, as well as the intervening elevations, were seen to correspond exactly to each other.

The only perceptible differences between the muscles of the crustacean and the striated muscles of the mollusk, appeared to be that the latter were much more finely striate; the striæ being six to eight times as numerous as in the former, in the same space. No difference between the striated and non-striated muscles of the *Acmæa* could be observed, except in the fact of the striation. In both the nuclei were irregularly distributed. The appearance of the striated fibre reminded one of a string of rhombic heads, which bore no relation to the position of the true nuclei. The striated fibers appeared, after a careful dissection of the parts in a number of specimens, to be the retractors of the radula; they were longer and in narrower bands than the non-striated fibers and comparatively much fewer in number. The striation was most evident toward the middle of the fibers and became evanescent toward their extremities.

Lebert and Robin (Müller's Arch. f. Anat. and Phys., 1846, p. 126) state that the primitive muscular fasciculi of invertebrates often have the nuclei and intervening clear spaces "arranged in such regular order that they might, at the first glance, be mistaken for transversely striated muscular fibers. The latter, however, are actually found in one acephalous mollusk, *Pecten*, (and probably in *Lima* also), and some annelids," and are constantly present in the voluntary muscles of *Crustacea* and *Insecta*. In the further researches of M. Lebert (Annales Sci. Nat., t. xiii, 1850, p. 161), he observes that there is nothing extraordinary in the discovery of transversely striated muscular fiber in *Polyzoa* (*Eschara*) by Milne Edwards, and in *Actinia* by Erdl, since "the further we have pursued the study of the comparative histology of muscular fiber, the more convinced we have become that transversely striated muscular fiber is to be found in a large number of animals of very inferior organization, without regard to their more or less advanced position in the animal kingdom."

Striated muscular fiber has lately been shown to exist in the "tail" or appendix of *Appendicularia* by Moss (Trans. Lin. Soc., vol. xxvii, p. 300). It was already known to exist in *Salpa*, (Eschricht, ov. Salperne), in the articulated brachiopoda, (Hancock, Tr. Roy. Soc., 1857, p. 805), and in *Pecten*, (Lebert, Annales Sci. Nat. 1850, 3rd ser., t. xiii, p. 166; and Wagner, Lehrb. d. vergleich. Anat., t. ii, p. 470, 1847), as well as in *Eschara* (Milne Edwards, Annales Sci. Nat., series ii, t. iv, p. 8). I believe, however, that this is the first instance in which it has been shown to exist in the class *Gasteropoda;* and this, as well as the rarity of such cases among the lower invertebrates, is a sufficient apology for bringing forward such an isolated fact. Other duties have not yet permitted me to determine whether this phenomenon is constant throughout the genus, or whether it does or does not occur among allied genera.

ART. XXII.—*Note to Article I, on the Quaternary of the New Haven Region;* by J. D. DANA.

As my statement in regard to the essential independence of the Connecticut valley glacier, and others, in the Glacial era may be misunderstood, I would draw attention to the meaning of the words "under the Continental glacier" in the note to page 2,—in which it is implied that such glaciers are but the inferior portions of the great Continental glacier. I hold that, while the very large valleys of the land, like those of the Connecticut and Hudson, had great influence in determining the direction of the movement in these valleys, especially that along the axis of each, the whole movement must have been more or less modified by the movement of the great northern ice-mass; and that the counteracting influence of a valley depended not only on its depth and extent, but also on its direction and slope. The smaller transverse valleys caused no modification of the general glacier movement; but large transverse valleys gave to the ice in the middle of the channel their own course almost unmodified: if not when the great ice-mass had its maximum thickness, at least afterward when it had become thinner and had lost some of its motion.

I may allude to one other example, as I believe it is, of a partly independent glacier—that of the St. Lawrence valley; for the scratches on its rocks correspond mainly with its course, the prevailing direction, according to Dr. Dawson, being northeast. It should be said that these scratches are attributed by Dr. Dawson to *icebergs* in the Glacial era, which are supposed to have moved southwestward up the valley, the land being profoundly submerged for the purpose, so as to allow of a discharge of the ocean over the continent in that direction; and the fact that boulders were transported *up* the valley is given as evidence in favor of this view. But, as in the case of the

Connecticut valley, icebergs could not have gathered up stones in the bottom of the valley for transportation; and, further, as the era following the Glacial—the Champlain era—was an era without question of submergence to a depth of at least 500 feet along the St. Lawrence valley, there should have been icebergs succeeding to the great St. Lawrence glacier and made from it before its final melting; and such icebergs may well have been driven up the river, then a broad arm of the sea, and thus have distributed southwestward the stones which had been gathered below by the glacier in the Glacial era, besides accomplishing all else that can rightly be attributed to icebergs.

ART. XXIII.—*Auroral Belt of October 24th–25th,* 1870.

THERE was seen at New Haven on Monday and Tuesday evenings, October 24th and 25th last, and at other distant places, in the United States, a belt of deep rose or crimson color from east to west across the southern sky, which possessed very uncommon, if not altogether novel characteristics,—among which the following may be instanced. *First,* its breadth was extreme. The writer estimated it at fifteen degrees, which is fully three times the ordinary breadth. *Second,* both its color and its consistence were wholly unlike anything seen at this place before, so far as is known, pertaining to this particular class of auroral phenomena. The "Aurora's Bow," as this class is called, has always hitherto displayed a yellowish white, like a mildly illuminated strip of cloud, and with a uniform cloud-consistence, although sometimes—very rarely—broken into parallel cross fleeces moving west. In this instance the bow was an assemblage of a few great masses irregularly bounded and illuminated, and in color resembling the ordinary red streamers deepened and darkened in hue. This color prevailed uniformly without intermixture with any other; but the component masses would progressively fade, without disappearing, and again recover brightness. *Third,* this class of arches has ever been noticed to form with suddenness and rapidity, and in motion southward to a stationary position, in which, after from twenty minutes to an hour, the arch would disappear. But in the present instance the bow was permanent, having, as here seen, the same situation, essentially, among the stars throughout Monday evening and night, and the like on Tuesday evening so far as the prevalent mists of that evening would allow observation. In parts of New Jersey, and south of Philadelphia, it appears to have kept nearly one place for forty-eight hours. *Fourth,* these arches hitherto have occupied the position of small circles in the northern hemisphere; but this occupied, here, a great circle, at least from ten o'clock on Monday night to one o'clock on Tuesday morning,—and approximately, the same for two hours earlier in the evening. This position lay centrally in the circle through or near the stars Alpha Aquilæ, Zeta Aquarii. Eta Ceti and Gamma Eridani; to which last it extended at midnight of Monday and after. At a time during the earlier hours, after nine o'clock and probably at about half past nine, the accurate observer Mr. Willard J. Gibbs, viewing this from an elevated station, concluded that the arch cut the western horizon at or near W. 8° N., and the eastern not farther from the south than S. 28° E. This would consist only with its being, at that time, a small circle in the southern magnetic hemisphere. Its path otherwise and its culmination were not noted by Mr. Gibbs. It deserves mention also that an observer of trustworthy accuracy describes the position in the due southeast, at two minutes before six o'clock, as being at that time nine degrees more south than the then position of the great circle above described would give it. Therefore in comparing mine with any observations made at other places earlier than ten o'clock New Haven time it would be prudent to allow for the culminating point at this place a few degrees of southing compared with the culmination of the circle described,—but not more than three degrees at nine o'clock and six degrees at eight o'clock.

At about this last mentioned time the belt was carefully located by observation made at Burlington, N. J. (115½ miles S. 50° 22′ W. from New Haven), by B. V. Marsh, Esq., who with others observed the phenomena during the evening of Monday, and until half an hour past midnight (Oct. 24th.) From Mr. Marsh's letters to Professor Newton descriptive of the belt I make extracts as follows:— "During all this time—say six hours—a crimson arch (more or less perfect) extended from near the N.E. horizon to near the N.W. horizon varying but little in position. At eight o'clock I noted its position with some care—by the aid of a globe. Its northern edge (which however was *not* sharply defined or very regular) passed about 25° S. of the zenith, and if continued would, I thought, have cut the horizon about N. 45 W. The arch or band was from 10° to 20° wide, perhaps 15° on an average. The color was a very deep crimson (at times) and was especially conspicuous in the N.W. and N.E., although very bright near the meridian also. There was in the north an imperfect and rather faint arch of streamers of a yellowish white color with a dark segment below. Up to half past ten o'clock there was no waving or flashing, but later there was considerable activity that way. Between ten and half past ten the arch seemed to cross the zenith a few degrees farther south than at eight o'clock." In a subsequent letter Mr. Marsh states "the arch [north edge] would have cut the horizon but little if any N. of East. The crimson light reappeared in nearly the same position the next evening."

Referring these statements concerning the north edge of the belt to its central line; it appears that the latter cut the horizon at about W. 30° N. and E. 15 S. and culminated about S. 22° W., having a zenith distance at eight o'clock of 32½°. The culmination at New Haven (lat. 41° 18′) at the same absolute time, was near S. 20 W. and at 44½° in altitude, allowing five degrees and a half southing from the great circle, for the reason just stated, giving a *corrected* difference of parallaxes—21° oblique to the meridians—of 10½°+, and concomitant to a difference of bases or chords of 100¼ miles:—which bring out a height of 339 miles vertical in lat. 37° 18′·4, or 1° 35′ south of Washington. This would imply that the belt, as seen at Washington, culminated more than 19° south of the zenith. According to the printed account of what was seen at that place — a copy of which in manuscript the writer has received from a trusted correspondent, and has given below—that observed distance was, in fact, but 9°;—however, the tendency to underestimate angular distances near the zenith is so universal that it would not be strange or unexpected to find nineteen degrees of zenith distance described as only nine degrees. This view is confirmed, in the present instance, by the analogous contracted estimate of breadth; which is called but 8°, when, from its nearer proximity to Washington than to Burlington, or to New Haven, it might be expected to subtend an angle of at least 16° or 20°. The account from Washington referred to is the following:—

"October 24—There is a very unusual auroral display to night. The northern sky to the elevation of 30° is brilliant with white light; but a distinct feature consists of a band of blood-red color starting from a point only 8° or 10° N. of W. passing 5° S. of the zenith and touching the horizon again a little S. of East. The breadth of the band is about 8°, and it is very strongly defined throughout."—The probability really is, in accordance with what has been suggested, that, instead of 5°, the north edge passed south of the zenith by as much as 10°, and its middle line nearly as much in addition. The foregoing conclusions are thus substantially confirmed by the observation at Washington; and they make the belt to have been about vertical to Richmond in Virginia,—while it must, equally, have been brilliant not only in central Virginia but through the Carolinas. Investigation will doubtless bring to light the means of a yet more complete and accurate determination of the height and position.

The position of the belt on Tuesday evening, the 25th, is thus described in a letter from W. C. Taylor, Esq., of Philadelphia as seen by him at $9^h\ 35^m$ P. M., at a station seven miles E.S.E. from Philadelphia. "The breadth of the crimson was tolerably uniform, having an average of about 12°. The general direction of the most distinct portion would be indicated by a line through Altair, the trapezium in the Dolphin, and 2° north of the southeastern star in the square of Pegasus." By this evidence it appears that the belt held a more northern situation at that time than upon the preceding evening. Mr. Marsh informs me that the same was seen to continue, during the evening without "apparent change of position" and until the next morning, by an acquaintance of his—a citizen of Philadelphia—who was traveling from that city to Richmond. He also states that the brilliant crimson light in the northwest had been seen on Monday morning. The same, it appears by the newspapers, was seen also at Cincinnati on that morning in the northeast, "resembling the lights of an immense fire," and also at St. Louis "illuminating the whole heavens as by a great conflagration."

It only remains to state respecting the aurora of Monday evening, as observed by the writer at New Haven, that by eleven o'clock the faint bank of yellowish white light which, together with a few streamers of a corresponding color, rested low in the north through the hours from six till ten and after, had become suddenly developed into a glowing sheet that covered the entire western, northern, and eastern sky,—everywhere striated and pillared in the western parts with red streamers, and with brilliant white, and pale yellow in the northeast and east. All these had as their base a low yellowish cloud arching over a well defined dark space, whose upper limit, in contact with the bright arch above it, extended about 55° from west of north to east of north, and 7° or 8° high near the north. There were radiations which reached up to a corona having its position in the ordinary relation to the dipping needle's direction, and far north of the great east-and-west crimson belt. The illuminated and extended sheet was pervaded by incessant auroral waves that passed upward with an uncommonly well established and traceable propagation from the cloud arch to the corona, and with an angular velocity estimated to be 112° in a second. This great and rare magnificence maintained itself till one hour after midnight, and then, for the time at least, it passed away. A. C. T.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the Chlorides of Sulphur.*—Hübner and Guerout have investigated anew the chlorides of sulphur. The chloride S_2Cl_2, corresponding to hydrogen peroxide O_2H_2, is easily prepared by saturating sulphur with chlorine and distilling the product. A liquid is thus obtained boiling between 136·5–137°, which gave on analysis 47·63 per cent S and 52·48 per cent Cl, the formula S_2Cl_2 requiring 47·41 S and 52·6 Cl. The chloride thus obtained was then saturated with dry chlorine, the excess being removed by passing dry CO_2 through the liquid for three or four hours. A portion of the chloride thus prepared, on oxidation with nitric acid, gave 30·5 per cent S, and 69·3 per cent Cl, the formula SCl_2 requiring 31·07 per cent sulphur and 68·93 per cent chlorine. There are therefore, say these authors, two chlorides of sulphur; a non-volatile chloride Cl_2S, corresponding to water, and decomposed by heat, $(SCl_2)_2 = S_2Cl_2 + Cl_2$; and a volatile chloride S_2Cl_2, obtained from the former, and boiling at 136·5–137°.—*Zeitschr. Chem.*, II, vi, 455, Sept. 1870. G. F. B.

2. *On the soluble and insoluble forms of Sulphur.*—Berthelot has confirmed Lallemand's observation that sulphur, dissolved in carbon disulphide and exposed to sunlight, is converted into the

insoluble variety. But he has also shown that this change may be produced as well by the electric light and by that of burning magnesium, though not by the calcium light. He finds, too, that melted sulphur, fused at 130° and allowed to cool slowly in sunlight, becomes coated with a pellicle of insoluble sulphur; though if cooled in the dark, it remains unchanged. If, however, the solution of sulphur in carbon disulphide be saturated with any body which can cause the inverse conversion, as hydrogen sulphide for example, and the air be carefully excluded, no change takes place on exposure to light. Moreover, in all cases, the sulphur to be converted must first be fused; crystallized octahedral sulphur suffering no change by light. The rays effecting the change are the chemical rays; hence the inactivity of the calcium light.

Berthelot has also examined the thermo-chemical changes resulting from these transformations. For this purpose, it was necessary to determine the quantity of heat evolved or absorbed, 1st, in the solution of the octahedral sulphur; 2d, in the fusion of this sulphur; and 3d, in the conversion of this variety into the insoluble form. The first of these determinations was not difficult; one gram of sulphur, in dissolving in carbon disulphide, absorbs 12·8 calories. The second datum was derived from the observations of Person which show that, in fusing, one gram of octahedral sulphur absorbs 9·4 calories. The third determination was more difficult; the inverse change of insoluble to ordinary sulphur takes place at 112°, and is accompanied by an evolution of heat; but this cannot be applied to the changes at common temperatures. Insoluble sulphur may be converted in the cold, by placing it in contact with a solution of hydrogen sulphide. This action, which alone is too slow for the purpose, may be completed in from 30 to 40 minutes, by adding to the solution of hydrogen sulphide a tenth of its volume of alcohol, no other chemical change being produced. This transformation thus modified, was effected in a calorimeter. As a mean, it appeared that at 18·5°, one gram of insoluble sulphur evolves on conversion, 2·7 calories. Upon dissolving the converted sulphur in €S_2, however, Berthelot found for each gram an absorption of 15·4 calories, nearly one-fourth more than that absorbed by the solution of the octahedral variety. From which he concludes that the freshly converted sulphur is a distinct variety, and gives it the name of *soluble amorphous sulphur*. Under the microscope, it appears in utricular masses like the insoluble sulphur; but in the course of a few hours, crystalline points appear on these masses, and the whole becomes crystalline in a few weeks. A new determination gave an absorption of 13·1 calories for each gram of sulphur; showing that now the amorphous was converted into the crystalline sulphur. Moreover, the amorphous sulphur, when dissolved in €S_2 can be obtained again only as octahedral sulphur. Since, then, the change of the soluble amorphous sulphur into octahedral sulphur is attended with an *absorption* of 2·6 calories, and the change from the insoluble variety into the amorphous soluble form, is attended with an *evolution* of 2·7 calories, sensibly the same quantity, it follows that no change of temperature accompanies the conversion of insoluble into octahedral sulphur.

From the data thus obtained, proving that, both in solution and when melted, an evolution of heat accompanies the conversion of ordinary octahedral sulphur into the insoluble variety, under the influence of light, Berthelot concludes that in these changes, the light does not effect the work of the transformation, but is simply the exciting agent.—*Bull. Soc. Ch.*, II, xiv, 106, Aug., 1870.

G. F. B.

3. *On the remarkable changes of color produced in certain iodides by heat.*—In some experiments upon the preparation of double iodides, **Meusel** found that on adding a solution of silver nitrate to one of mercuric iodide in potassium iodide, a bright lemon-yellow precipitate was thrown down, which, on slightly warming the solution, became intensely orange-red, but regained its yellow color on cooling. Further experiments showed that the same property was possessed by mercuric-cuprous iodide. If to a warm solution of mercuric iodide in potassium iodide, copper sulphate and then sulphurous acid be added, a brilliant carmine-red precipitate is obtained which becomes intensely black on heating to 70°. At first, these bodies were considered to be definite double iodides; but Meusel, finding that they may be prepared by mixing together the separate iodides under water, and that the precipitated substances may be partially separated mechanically, concludes that they are mixtures, and accounts for the change of color by a variation in the absorptive power for light of the silver and the cuprous iodides respectively at different temperatures.

Willm and **Caventou**, on the other hand, maintain that these precipitates are true double iodides. The cuprous mercuro-iodide, they assert, gives up nothing to a cold solution of KI, has the definite formula $Hg(\text{Є}u_2)I_4$, and yields two definite crystalline products when treated with ammonia.

Boettger suggests moistening these powders with a little weak gum-water and drawing devices with them on paper. The change of color by heat is then easily shown as a striking lecture-experiment.—*Ber. Berl. Chem. Ges.*, iii, 123, 1870. *Bull. Soc. Ch.*, II, xiii, 220, 1870. *J. pr. Ch.*, II, ii, 136, Aug. 1870. G. F. B.

4. *On Tetramethylformene.*—Three isomeric hydrocarbons belonging to the marsh-gas series, Є_nH_{2n+2} and containing five atoms of carbon, Є_5H_{12}, are theoretically possible:

$$1.\ \text{Є}\left\{\begin{array}{l}\text{Є}H_2\text{Є}H_3\\ H\\ H\\ \text{Є}H_2\text{Є}H_3\end{array}\right. \qquad 2.\ \text{Є}\left\{\begin{array}{l}\text{Є}H_3\\ \text{Є}H_3\\ H\\ \text{Є}H_2\text{Є}H_3\end{array}\right. \qquad 3.\ \text{Є}\left\{\begin{array}{l}\text{Є}H_3\\ \text{Є}H_3\\ \text{Є}H_3\\ \text{Є}H_3\end{array}\right.$$

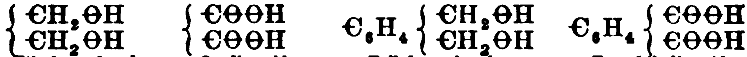
Of these only the second, prepared from amyl alcohol, has, until recently, been obtained. Lwow, under the direction of Professor Butlerow, has succeeded in forming the third, by acting upon tertiary butyl iodide with zinc methyl, according to the equation:

$$(\text{Є}(\text{Є}H_3)_3I)_2+\text{Ƶ}n(\text{Є}H_3)_2=(\text{Є}(\text{Є}H_3)_4)_2+\text{Ƶ}nI_2.$$

The zinc methyl was added by drops to the butyl iodide, and the evolved gas washed with dilute HCl, and collected in well-cooled alcohol. On diluting the saturated alcohol solution with water, the new hydrocarbon was evolved as a gas, which, conducted into a well-cooled receiver, condensed to a liquid. This was freed from other hydrocarbons by treatment, first with bromine and then with sodium. Fifty grams of tertiary butyl iodide and 13 grams zinc methyl, gave 15 grams of pure $Ɛ_5H_{12}$, almost the theoretical quantity. The hydrocarbon thus obtained is a colorless, mobile liquid, boiling at 9·5°, and solidifying at $-20°$ in crystals, resembling sublimed sal-ammoniac. This remarkable solidification by cold, is characteristic of all highly methylized compounds, as trimethylcarbinol, methyl oxalate, tetramethylbenzol or durol, etc. Analysis established the formula $Ɛ_5H_{12}$; a determination of the vapor-density by Hofmann's method, gave 2·495, the calculated density being 2·493. This hydrocarbon, it will be seen, is marsh-gas, in which all four atoms of hydrogen are replaced by methyl. Berthelot's name for marsh-gas being formene, this body has received the name tetramethylformene. It is distinguished from isoamyl hydride by the facility with which it crystallizes. —*Zeitschr. Chem.*, II, vi, 520, Nov. 1870. G. F. B.

5. *On an aromatic glycol.*—Although Wurtz prepared the first glycol, or diatomic alcohol of the fatty series in 1856, yet no similar body belonging to the aromatic series has, until now, been obtained. Such a body GRIMAUX has recently succeeded in producing. Starting with the fact that xylol, $Ɛ_8H_{10}$, may be viewed as di-methyl benzol $Ɛ_6H_4\left\{\begin{matrix}ƐH_3\\ƐH_3\end{matrix}\right.$, Grimaux treated it at a boiling heat, with chlorine expecting to obtain either a chloride analogous to ethylidene chloride and corresponding to an aldehyde, $Ɛ_6H_4\left\{\begin{matrix}ƐHCl_2\\ƐH_3\end{matrix}\right.$, or one analogous to ethylene chloride, and corresponding to the hydrochloric ether of a glycol, $Ɛ_6H_4\left\{\begin{matrix}ƐH_2Cl\\ƐH_2Cl\end{matrix}\right.$. The chloride in question was first prepared in 1867, by acting with chlorine upon xylol obtained from coal-tar, heated to 140°. The yield was very small, however; a fact since accounted for by Fittig's discovery that the xylol from coal-tar is a mixture of 90 per cent isoxylol, and 10 per cent methyl-toluol, from the latter of which alone the above chloride is formed. Investigation having proved that the chloride thus obtained was the second of those given above, Grimaux proposes the name *tollylene* for its radical $Ɛ_8H_8$, or $\left(Ɛ_6H_4\left\{\begin{matrix}ƐH_2\\ƐH_2\end{matrix}\right.\right)''$. The body $Ɛ_6H_4\left\{\begin{matrix}ƐH_2Cl\\ƐH_2Cl\end{matrix}\right.$ is therefore tollylene chloride. By solution in chloroform and crystallization, it is obtained in the form of hard, transparent, rhomboidal prisms, fusing at 100° and distilling above 230°. Heated with water, it yields tollylene glycol; treated with alcoholic solutions of sodium acetate or benzoate, it forms tollylene diacetate or monobenzoate. It yields terephthalic acid by oxidation with potassium dichromate and sulphuric acid. The tollylene glycol,

$C_6H_4\left\{\begin{matrix}CH_2\Theta H\\ CH_2\Theta H\end{matrix}\right.$, was obtained from the chloride, as above, by heating it in a close vessel to 170–180° with thirty times its weight of water. The saponification was complete at the end of two hours, and by evaporating the water the glycol crystallized in needles, which, after purification, were found to fuse at 112–113°, to be very soluble in water, alcohol, and ether, and to yield terephthalic acid by oxidation. The analogy of these two bodies to ethylene glycol and its corresponding acid, Grimaux shows by writing them as follows:



$$\left\{\begin{matrix}CH_2\Theta H\\ CH_2\Theta H\end{matrix}\right. \qquad \left\{\begin{matrix}C\Theta\Theta H\\ C\Theta\Theta H\end{matrix}\right. \qquad C_6H_4\left\{\begin{matrix}CH_2\Theta H\\ CH_2\Theta H\end{matrix}\right. \qquad C_6H_4\left\{\begin{matrix}C\Theta\Theta H\\ C\Theta\Theta H\end{matrix}\right.$$

Ethylene glycol. Oxalic acid. Tollylene glycol. Terephthalic acid.

—*Bull. Soc. Ch.*, II, xiv, 133, Aug. 1870. G. F. B.

6. *On the production of solid cresol.*—**Wurtz** proposed some time ago, a method for converting the aromatic hydrocarbons into phenols. This consisted in treating the hydrocarbons with sulphuric acid, and then decomposing the sulpho-acids thus obtained, by potassium hydrate in excess. In a recent experiment, 300 grams of toluol were converted into cresyl-sulphurous acid, and the potassium cresyl-sulphite fused in a silver basin with a mixture of potassium and sodium hydrates. This fused product, on treatment with hydrochloric acid, yielded 200 grams of crude cresol, boiling above 190°, the larger part at 198° to 204°. On cooling these latter products, a solid mass was deposited, which, after washing with ether, had a brilliant white, lustrous appearance and a strong odor of phenol. It melted at 34·5° and boiled at 201·5 to 202°.—*Bull. Soc. Ch.*, II, xiv, 6, July, 1870. G. F. B.

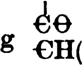
7. *On the synthesis of aromatic acids.*—Erlenmeyer and Gütschow having shown that sodium formate, when heated alone, is broken up into hydrogen and sodium oxalate, **Victor Meyer** concluded that at a certain instant of this change, both hydrogen and the carboxyl group $(C\Theta\Theta Na)'$ existed in the nascent state; and therefore, that if sodium formate were fused with the potassium salt of an aromatic sulpho-acid, its hydrogen would combine with the group $(S\Theta_3K)'$, while its carboxyl group would replace it, according to the equation:—

$$RS\Theta_3K+H(C\Theta\Theta Na)=HKS\Theta_3+R(C\Theta\Theta Na).$$

Equal quantities of dry sodium formate and potassium phenylsulphite were intimately mixed and fused for several minutes, with constant stirring, in a porcelain dish. The brown mass was dissolved in water, acidulated, and distilled, the distillate made alkaline with soda, boiled with animal charcoal to free it from sulphur compounds, concentrated by evaporation, and treated with hydrochloric acid. A copious precipitate of benzoic acid was thrown down, which by recrystallization and sublimation, was obtained pure. In another experiment, equal parts of sodium formate and potassium sulphobenzoate were intimately mixed together and then fused. The reaction took place more easily and uniformly than in the former case, and at a lower temperature. On dissolving the mass in water and acidulating the solution, ether extracted an acid from it which was proved to be isophthalic acid.—*Ber. Berl. Chem. Ges.*, iii, 112, Feb., 1870.

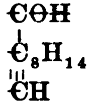
G. F. B.

8. *On the constitution of Camphor.*—VICTOR MEYER has also investigated the constitution of common camphor, which, though the substance has long been known and has been chemically examined repeatedly, has never yet been satisfactorily determined. Of its reactions, the two most important are the production of cymol when acted on by substances capable of withdrawing water from it, and the almost unique production of a dibasic acid by the direct union with it of three atoms of oxygen. The hope of getting some light on this question from the production of phorone alike from calcium camphorate and from acetone, is destroyed by Baeyer's observation that these two phorones are isomeric and not identical. Meyer begins therefore, with the study of camphoric acid. This acid is dibasic; but it possibly does not contain two carboxyl groups, being perhaps an oxy-ketonic acid, containing one carboxyl group, together with the grouping

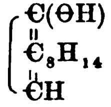


$$\begin{matrix} | \\ \text{ȻΘ} \\ \text{ȻH(ΘH)} \\ | \end{matrix},$$

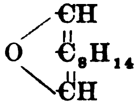
as Weyl has suggested. To test this question, camphoric acid was distilled with soda-lime, in the expectation, that, were two carboxyl groups present, $(\text{ȻΘ}_2)_2$ would be removed, leaving the hydrocarbon $\text{Ȼ}_8\text{H}_{16}$. Owing, however, to the low temperature at which camphoric acid breaks up into the volatile anhydride and water, no hydrocarbon was obtained. The observation of Moitessier, however, that copper camphorate yields on dry distillation $(\text{ȻΘ}_2)_2$ and a hydrocarbon $\text{Ȼ}_8\text{H}_{14}$, was confirmed; a fact which Meyer regards as making probable the existence of two carboxyl groups. To test Weyl's view positively, the fact that all known ketonic acids are reduced to oxyacids by nascent hydrogen was made use of, and camphoric acid was treated with sodium amalgam for a week; but without change. Lastly, it was proved that no third hydroxyl group was contained in this acid, by heating ethyl camphorate $\text{Ȼ}_{10}\text{H}_{14}\text{Θ}_4(\text{Ȼ}_2\text{H}_5)_2$ with excess of acetyl chloride in a sealed tube for several days; no change was observed in the ether. From these facts, Meyer gives the formula of camphoric acid as $\text{Ȼ}_8\text{H}_{14}\left\{\begin{matrix}\text{ȻΘΘH}\\ \text{ȻΘΘH}\end{matrix}\right.$. Remembering now the second fact above given, that camphor, by loss of water, gives cymol, a homologue of benzol, it is probable that six of its carbon atoms form a main chain, the other four being in the form of lateral chains. Moreover, two of the carbon atoms in the main chain must take up oxygen in its oxidation, else there would be a separation of hydrogen as water; and lastly, the production of cymol shows that the carbon atoms yielding the two carboxyl groups are not united to the same carbon atom. Writing therefore, the formula of camphoric acid $\left\{\begin{matrix}\text{ȻΘΘH}\\ \text{Ȼ}_8\text{H}_{14}\\ \text{ȻΘΘH}\end{matrix}\right.$, camphor itself may have one of the three following formulas :—



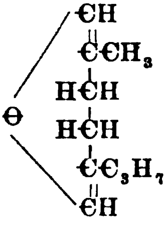
$$\begin{array}{l}\text{ЄΘH}\\ \vert\\ \text{Є}_8\text{H}_{14}\\ \vert\vert\vert\\ \text{ЄH}\end{array}$$



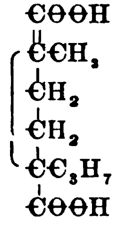
$$\left[\begin{array}{l}\text{Є(ΘH)}\\ \vert\vert\\ \text{Є}_8\text{H}_{14}\\ \vert\vert\\ \text{ЄH}\end{array}\right.$$



The first of these formulas makes camphor an aldehyde. But this view, though proposed long ago by Berthelot, cannot be held since Tollens and Fittig showed that camphor possessed none of the characteristic properties of an aldehyde. According to the second formula, camphor contains a hydroxyl group and is a kind of alcohol. This is rendered improbable by Berthelot's experiments, who found that while borneol, which is an alcohol, formed an ether with acid hydrates, camphor was entirely indifferent to them. Moreover, Meyer treated camphor with acetyl chloride, with glacial acetic acid, and, in alcoholic solution, with hydrochloric acid gas, without changing it in the least. Hence, camphor contains no hydroxyl group. The third formula therefore is the only one possible. The constitution of the nucleus $\text{Є}_8\text{H}_{14}$ is to be interpreted from that of the camphor-cymol, which, as Fittig, Kōbrig and Jilke have shown, is either diethylbenzol or methyl-propyl (or isopropyl) benzol. Adopting the latter view, we have for the rational constitution of camphor and camphoric acid, the following formulas:

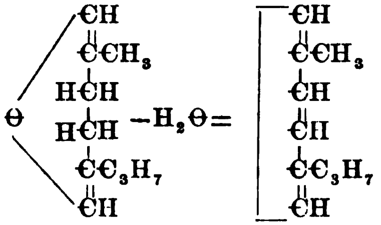


Camphor.



$$\left[\begin{array}{l}\text{ЄΘΘH}\\ \vert\\ \text{ЄЄH}_3\\ \vert\\ \text{ЄH}_2\\ \vert\\ \text{ЄH}_2\\ \vert\\ \text{ЄЄ}_3\text{H}_7\\ \vert\\ \text{ЄΘΘH}\end{array}\right.$$

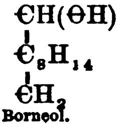
Camphoric acid.



Camphor.

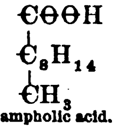
Cymol; or Methyl-isopropyl-benzol.

The reaction above given explains very simply the formation of cymol; by loss of water, the hydrogen-atoms of the third and fourth carbon atoms take out the oxygen, thus doubly uniting these carbon atoms and combining the end carbon atoms into the closed chain characteristic of the aromatic series. Moreover, in the camphor formula the carbon chain is not closed. Hence, the lateral chains remain intact during oxidation; while in true aromatic compounds, which contain closed chains, the lateral chains are always the ones oxidized. The following formulas are given by Meyer for borneol and for campholic acid.



$$\begin{array}{l}\text{ЄH(ΘH)}\\ \vert\\ \text{Є}_8\text{H}_{14}\\ \vert\\ \text{ЄH}_3\end{array}$$

Borneol.



$$\begin{array}{l}\text{ЄΘΘH}\\ \vert\\ \text{Є}_8\text{H}_{14}\\ \vert\\ \text{ЄH}_3\end{array}$$

Campholic acid.

—*Ber. Berl. Chem. Ges.*, iii, 116, Feb. 1870. G. F. B.

9. *A Text-book of Elementary Chemistry, Theoretical and Inorganic;* by Geo. F. Barker, M.D.—Prof. Barker's excellent treatise has already been briefly noticed in this Journal, and we propose now to call attention somewhat more in detail to its advantages and merits as an elementary work. The first 86 pages are devoted to Theoretical Chemistry, which is here made to include stœchiometry, nomenclature and the general theory of combination. The remainder of the work is occupied with descriptive inorganic chemistry. Each chapter terminates with a series of questions always valuable but particularly useful in making the student thoroughly acquainted with the introductory or theoretical portion of the work, which is wholly in the spirit of the most advanced thought in the science. To the author's nomenclature we take some exceptions. Such terms as *potassium chlorate*, *calcium phosphate*, &c., though employed by many English chemists at the present day, are, to say the least, of doubtful etymological propriety, and we greatly prefer the corresponding adjective forms, *potassic chlorate*, *calcic phosphate*, &c., while admitting that these are not always of easy application. Dr. Barker himself occasionally employs the adjective forms, and will, we hope, carry them out systematically in future editions. On the other hand, however, we heartily agree with him in rejecting the absurd term "anhydride," which denotes, not what a substance does but what it does not, contain, and in employing such names as sulphurous and sulphuric oxide for $S\Theta_2$ and $S\Theta_3$, nitrous and nitric oxide for $N_2\Theta_3$ and $N_2\Theta_5$, &c., adopting the form *carbonic dioxide* for $C\Theta_2$ to avoid confusion. With the author's original views as to the constitution and nomenclature of the ortho-acids and bases and their derivatives, we also entirely agree. The descriptive part of the work is carefully and judiciously compiled, omitting unnecessary and burdensome detail. Upon the whole we find in Dr. Barker's work a concise, logical and clear treatise, well adapted as a first book, and we sincerely hope that it may be followed by a similar work on Organic Chemistry. W. G.

II. Geology and Natural History.

1. *A Reply to Mr. Dall's criticism on the Brachiopods as a division of the Annelids;* by Edward S. Morse.—The July number of this Journal contained a brief abstract of a verbal communication made by me before the Boston Society of Natural History, on the "Brachiopoda as a division of the Annelida."* I did not expect the concurrence of conchologists to the view there advanced, for I recalled the manner in which an eminent conchologist of England, Mr. Sowerby, received the announcement by Thomson that the Cirripeds were Crustaceans. So in this question, the Conchologists, so far as I am aware, oppose it. While any impartial review would have been answered in my

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* Since republished from this Journal in the Annals and Mag. Nat. History, London.

memoir now in preparation, it seems proper that a reply should be made to a criticism contained in "a Revision of the Terebratulidæ and Lingulidæ, etc.," by Wm. H. Dall, and published in the American Journal of Conchology, vol. vi, part 2. While thanking Mr. Dall for his kindly notice of my labors, and appreciating fully the value of the work he is engaged in, as comprised in his communications to the above named Journal, I am yet compelled to plainly criticize the manner in which he has presented the question in his review.

Mr. Dall says that the "utmost impartiality" should be used in the discussion and "due consideration should be given to the facts," etc. This "utmost impartiality" is illustrated, by passing over in absolute silence, not only all my references to the limited knowledge we possess of the embryology of the Brachiopods as shown by Lacaze Duthiers, but the dorsal and ventral plates—the serial arrangement above and below of setæ, and even the gill laminæ in *Lingula*, as first recognized by Savigny in the annelids—the bi-lobed lophophore—the cephalic collar—the thin and muscular visceral walls—the singular results obtained by Gratiolet in the chemical analysis of the shell of *Lingula anatina*—the presence of the cæcal prolongations of the mantle, and their relations to the *porenkanale* in the annelids—and, above all, the remarkable existence of one or more pairs of *segmental organs*, in form, character and functions like the segmental organs of the annelids, the first feature that led me to regard the Brachiopods as annelids six months before I ever saw living *Lingulæ*. All these points are passed over in the "utmost impartiality" of silence. Overlooking with the same impartiality my statement that the Brachiopods presented a *comprehensive type*, and comprised certain crustacean characters, he neglects to mention the winter egg of the Polyzoa and similar features in the lower Crustacea, and we might add similar features in certain rotifers now admitted to be worms. So also the presence of striated muscular fiber in certain muscles of the Brachiopoda, their absence in the Mollusca, and their presence as one of the prominent characters in Crustacea. He gives us, however, Clark's definition of the Mollusca which comprise the characters of the branch as then understood, which includes of course the Tunicata, Polyzoa and Brachiopoda. In defining the Vermes, with the same impartiality, reference is made only to those Vermes in which the body is made up of a repetition of similar parts, overlooking entirely the unisegmental Vermes which comprise a large proportion of the class; nor is reference made to the remarkable cephalization of many Annelids, where the posterior portion of the body has been called a caudal appendage, being without bristles. In some, the thoracic rings, few in number, have a wide flaring membrane running continuously along each side (*Protula.*)

We leave others to judge of his conclusions respecting the character of the setæ, as also his startling homology of the peduncle of *Lingula*, and the syphonal tubes of a clam (!) and call attention to his statement, that because the setæ are not found the entire length of the peduncle, therefore they are by no means "identical" with those of the worms. This will be a new idea to naturalists, that the confinement of appendages to limited portions of the body, forbids all homology with those in which the appendages run the entire length. It indicates also that Mr. Dall believes that all Chætopods have setæ from head to tail.

He states as a grave objection that the Brachiopods are invariably attached by muscles to a bivalve shell. In the same breath he should have added that worms are also invariably attached to a *bivalve* or multivalve shell, whether it be the scuta of *Sternaspis*, the oval plates of *Lepidonotus*, or the hardened integuments of others.

He lays great stress on the presence of bristles in Chiton, as if that group were the very embodiment of the Molluscan type, but with the same impartiality he neglects to mention its embryology, so remarkably articulate as shown by Lovén, its dorsal vessel, the double and forward opening of the oviducts, the anus terminal, and other features so remarkably articulate, as to induce De Blainville to recognize their affinities with the annelids, to prompt Milne-Edwards to call them a Satellite group, and to cause Jeffries to liken them, in their different stages, to "Isopods, tiny trilobites, Onisci and Aphrodita."

In mentioning my anatomical drawing of various Brachiopods, he says, "some of them taken from life," he should have said, "most of them taken from life."

In concluding his paper he refers to drawings in my collection of a "singular sipunculoid worm," "and appears from them, to have an anterior termination to the intestine, thus forming a notable exception to the general rule among worms." The drawing to which he refers is the common sipunculoid worm of the coast. *Phascolosoma*, *Sipunculus* and its allies claim it as a right to have an anterior termination to the intestine, a fact known to every one who ever made them a study. Finally, in his comparisons, with the exception of Chiton, he confines himself to, and only points out a few of the many relationships between the Brachiopods and Polyzoa and Tunicates, admitted by all. Now since Leuckart, Gegenbaur, Haeckel, and other eminent naturalists of Europe, have seen conclusive reasons to remove the Polyzoa and Tunicates entirely from the Mollusca, and place them among the Vermes, it seems that Mr. Dall's first task should be to whip these back to the Mollusca, before commencing with the Brachiopods.

2. *On Eozoon Canadense;* by Prof. Wm. King, S.C.D., and Thos. H. Rowney, Ph.D., of the Queen's Univ. in Ireland, and the Queen's College, Galway. 42 pp. 8vo, with three colored plates, (Proc. Roy. Irish Acad., July, 12, 1869).—The following Supplementary note to the paper noticed on page 68, was read Feb., 1870.

Within the last fortnight we have been successful in finding "eozoonal" structures under conditions which unmistakably establish their origin.

We have first to notice a specimen of ordinary metamorphic micro-crystalline limestone, from Aker, in Sweden. It contains numerous light green grains of pyroxene of the variety known as coccolite, a considerable portion of a colorless translucent variety of a related mineral seemingly malacolite, and a few small purple spinels. The grains of coccolite, which have a rude cleavage approximating to a sub-conchoidal fracture, are isolated, or form aggregations, in the calcareous matrix: their surfaces are variously rounded and excavated, giving the grains an irregularly lobulated appearance. The occasional presence of planes, edges, and solid angles on their surfaces, renders it certain that the grains were originally crystals that have undergone superficial erosion by some dissolving agent. The spinels, which are in octahedrons, have been subject to a similar waste, though not to the same extent—only occasionally occurring more or less spherical, and with eroded surfaces.

In their irregular lobulated character, variety of aggregation, and scattered arrangement, the grains of coccolite strikingly resemble those of serpentine ("chamber casts") in the "acervuline" variety of "*Eozoon Canadense*," occurring in Canada. We take credit for being the first to point out a precisely similar agreement in the grains of chondrodite, pargasite, &c., common in the crystalline limestones of other places.*

But the specimen under notice shows other and additional characters, which still more clearly establish its "eozoonal" relationships.

When a slight portion of the matrix is removed by decalcification, the surface is seen to be crowded with slender cylindrical forms, more or less branching, often remarkably beaded, and arranged in all conceivable modes of grouping. They agree in every respect with the finest typical examples of the "canal system," as represented by Doctors Carpenter, Dawson, and Professor Rupert Jones.†

Associated with the latter are numerous specimens of the malacolite, divided by different sets of cleavage planes, the principal one giving them quite a lamellar structure. Occasionally others occur approximating more or less to perfect prismatic crystals: but generally some of the angles, edges, and planes, have disappeared, or only traces are observable; so that they present the appearance of vermicular rods—straight, bent, or twisted—nodulose, or irregularly excavated. These configurations exactly answer to certain of the so-called "stolons."‡

It may be contended, by those from whom we differ on the question discussed in these pages, that the specimen belongs to an "eozoonal" rock. But, apart from its fatal agreement with other specimens of the kind in possessing the never-failing crystalline or metamorphic character—how, on such a view, are we to set aside the clear evidences of the "chamber casts" and the "stolons" having been originally crystals?

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* "Quarterly Journal of Geological Society," vol. xxii, p. 209.

† See Dawson in "Quarterly Journal of Geological Society," vol. xxi, Pl. VII, figs. 3, 4, 5; Carpenter, ibid, Pl. VIII, fig. 5, *a*, *b*, *c*, and Pl. IX, fig. 5, *a*, *b*, *c*, *d*; Rupert Jones, "Popular Science Review," vol. iv, Pl. XV, figs. 6, 7, 8.

‡ See Carpenter, "Quarterly Journal of Geological Society," vol. xxi, Pl. VIII, fig. 3, Pl. IX, fig. 3; Jones, "Popular Science Review," vol. iv, Pl. XV, fig. 5.

Besides, not only have these parts had a crystalline origin, but it is equally plain that the same conclusion must embrace the "canal system;" for it is impossible to detect any line of demarcation between the "stolons" and the latter. Dissolving action has, in the first place, converted the crystals of malacolite into the "stolons:" next the crystals were divided by cleavage, and eroded to such an extent that, in the state of the "canal system," they became reduced to mere skeletons.* Respecting the beaded character of the branching forms, we are strongly inclined to believe that it has resulted from the cleavage which transversely cuts the prisms: obviously the erosion would be deepest where it was present.

In no instance have we detected any traces of the "nummuline layer" on the grains—a deficiency we attribute to their component mineral, coccolite, not assuming the fine asbestiform structure which so eminently distinguishes serpentine in its change into chrysotile. There is often, however, a thin whitish granular coat investing the grains, sometimes so compact as to remain after they have been accidentally detached from the matrix.

Another specimen, which is from Amity, New York, consists of a similar calcareous matrix, holding spinel, chondrodite, serpentine, a micaceous mineral, and malacolite. One of the crystals of spinel is a compound octahedron, about two inches in its axial diameters, having part of its faces built up of minute triangular facets, and others, of small implanted octahedrons; both lying parallel to the faces of the large crystal. Numerous linear chinks, and irregularly formed cavities, separate the component triangular facets and octahedrons; and they are filled up with micro-crystalline calcite, similar to that of the matrix, enclosing malacolite. Decalcification brings out beautifully the last-named mineral, which assumes with wonderful exactness all the characters and modifications of the "stolons" and "canal system," as displayed in the Aker specimen; so that the description we have given of them would have to be repeated if we described those under consideration: and were it necessary to represent the latter, our representations would be close *fac-similes* of the figures, already referred to, which Dawson, Carpenter, and Rupert Jones, have published in their respective memoirs.

All the calcite of the specimen equally shows the same "eozoonal" structures; and that they have originated from the waste of crystals of malacolite. One example consists of a prismatic or longitudinally-cleaved mass of this mineral, having at one end the cleavage prisms diverging, losing their edges, and slightly branching; strikingly resembling the case figured in our first memoir,* and reminding us of the example of the "canal system," described by Dr. Carpenter as "consisting of parallel lamellæ disposed like the leaves of a book."†

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* It may be hypothetically suggested that, in the final stage, the crystals have been totally dissolved. Malacolite consists, in round numbers, of silica 55, lime 23, magnesia 17. Assuming carbonic acid to have acted as the solvent, this substance might completely replace the silicic acid. and in this way change the basic constituent of the mineral; making calcite (or dolomite) a pseudomorph after malacolite.

Since it was first announced that we had determined "*Eozoon canadense*" to be nothing more than a mineral production, we have all along felt that specimens would be found demonstrating more and more completely the truth of our conclusion: but we were certainly not prepared to meet with a large crystal of spinel, holding in its chinks and cavities typical examples of two of the essential features of this reputed organism: and these themselves possessing evidences indisputably testifying to their purely crystalline origin.

The Aker and Amity specimens show, what we have long suspected, as intimated here and there in the preceding paper, that the arborescent forms ("canal system") may consist of other silicates besides serpentine. As to their being composed of anything else than a siliceous substance, we are not yet prepared to offer an opinion on the matter; though it must not be overlooked that similar forms, but on a comparatively gigantic scale, are common, consisting of carbonate of lime, in magnesian limestone, near Sunderland, in Durham. We have been led into this subject from observing a recent announcement, by Dr. Sterry Hunt, of *another* discovery in "*Eozoon canadense*" (at Chelmsford, near Lowell, U. S.) of "the canals and tubuli of the calcareous skeleton filled, not with a silicate, but with carbonate of lime."‡ On seeing this announcement, we immediately wrote to Mr. Bicknell, of Salem, mentioned by Dr. Sterry Hunt, asking him to oblige us with specimens of the kind. Shortly afterwards we received from Mr. Bicknell, by sample post, a transparent section carefully prepared by himself, and a piece of the rock,—both labelled "Chelmsford." There were also specimens of "eozoonal" ophite from Newberryport, a neighboring locality. In the latter, some of the structures are typically exhibited: the fibers of the "nummuline layer," however, are more confusedly arranged, and much longer than usual. In the former, the serpentine, of a pale-greenish color, is in irregularly fractured pieces, separated from one another by unusually wide interspaces of calcite ("calcareous skeleton,") which contains bundles of radiating crystals, also groups of vermicular branching forms ("canals and tubuli"): the "nummuline layer" is not well developed, being often represented by minute radiating aciculi. We have carefully tested the Chelmsford specimens, both by chemical reactions and polarized light, without however, detecting any evidence of the "canal system" being else than siliceous; or of being composed of a substance identical with or related to its calcareous matrix.* Now, we cannot dispute the statement of Dr. Sterry Hunt; as probably some mistake may have been made in our specimens. We must, however, *in this case too*, complain of the very meagre and unsatisfactory account given of the "canals and tubuli" in the otherwise more detailed notice of the Chelmsford "Eozoon," published in the Am. Journ. of Sci., p. 77, of January last. No evidence whatever is offered to show by what process the chemical nature of these parts was determined;—whether the conclusion that they are of the same composition as the "calcareous skeleton" was based on an examination by polarized light; or whether they do not consist of some soluble silica, or of a mixture of a carbonate and a silicate such as would be quite as readily acted upon by weak acid as their imbedding substance, especially if it be dolomite. We wish to call particular attention to the last point, as brief mention has already been made of a specimen of elæolite (a translucent variety, from Brevig), which, in consequence of its being an alkaliferous silicate of alumina (and there is no reason why such a compound may not occur in the Laurentian metamorphic marbles), was dissolved in weak acid. Another specimen, which we have lately subjected to the same process, was taken out of the solution in a partially digested state. When examined with the microscope, the residuum, which is in a slightly coherent condition, was found to consist of interlacing configurations, some of which, where well separated from the rest, bore no inconsiderable resemblance to the "canal system"—not, it is true, in its beautiful arborescent forms, but in the small crooked branching varieties, common to many Canadian examples. Prismatic cleavage, which elæolite eminently possesses, had evidently favored the development of the configurations. They are transparent, rudely branching and anastomosing, showing rarely any cleavage edges or planes; these for the most part having been emoved by the action of the acid.

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* "Quarterly Journal of Geological Society," vol. xxii, Pl XV, fig. 17, *b*.
† "Intellectual Observer," vol. vii, p. 294.
‡ "Scientific Opinion," January 20, 1870, p. 45.

Such a case as this clearly necessitates every point being duly considered before any conclusion can be drawn as to the chemical nature of the "canals and tubuli," should they appear not to have their ordinary composition. It also strikingly illustrates the view we have taken that these parts in typical "*Eozoon*" are merely the skeletons of fragments, or of crystals—respectively of serpentine or some other silicate—which remain after their waste had been arrested through changed conditions. Moreover, it testifies to our having succeeded in forming from elæolite, by the action of a weak solvent, configurations approximating to the rude varieties of the "canal system."

3. *Scientific Expedition to the Rocky Mountains.*—The Yale College scientific party, in charge of Professor O. C. Marsh, which left New Haven in June last for the Rocky Mountains, returned to this city on the 18th of December. The party, which was essentially a private one, consisted of Professor Marsh and twelve com-

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* We expect still to receive specimens, undoubtedly identical with those described by Dr. Sterry Hunt; when we hope to announce with more certainty the result of our investigations.

panions, all students or recent graduates of the College. The main object of the Expedition was to investigate the extinct vertebrate fauna of the Tertiary and Cretaceous deposits of the Rocky Mountain country, and the general plan adopted was to make several separate trips, of one or two hundred miles north or south of the Pacific railroad, to regions that were unexplored, or had never been carefully examined.

The first of these was made early in July, from Fort McPherson in Nebraska, to explore the Pliocene deposits along the Loup Fork river. Here rich collections of fossil vertebrates were obtained, and several new species of extinct mammals and birds discovered. The next expedition was made in August, from Fort D. A. Russell in Wyoming, to examine the geology of the country between the North and South branches of the Platte river. On this trip the Mauvaises Terres or "Bad land" formation, with the true *Titanotherium* and *Oreodon* beds was discovered in Colorado,* and traced northward through Nebraska to the North Platte. The fossil remains obtained were also important, and included several species of extinct mammals and birds, new to science.

The third expedition was made from Fort Bridger, Wyoming, in September and October, to examine the geology of the Eastern Uintah Mountains, and the country between the Green and White rivers. In this region interesting geological discoveries were made, and many new Tertiary vertebrate remains secured, which will soon be described by Professor Marsh. On their return, the party went to California, and spent a month in visiting various points of scientific interest; after which they came east to Denver, and thence to Fort Wallace in Kansas. About two weeks were spent in exploring the Cretaceous beds of this vicinity, where some interesting reptilian and fish remains were obtained, and the party then returned to the east.

The Expedition as a whole was very successful, and the large collections made will be placed in the Peabody Museum of Yale College. The more important scientific results will soon be published.

4. *Monograph of the North American Astacidæ;* by Dr. H. A. Hagen. No. III of the Illustrated Catalogue of the Museum of Comparative Zoölogy. Cambridge, 1870.—Our American craw-fish have been much neglected, never having been subjected to thorough study, and, as might be expected, Dr. Hagen has given us an accurate and very valuable monograph. The investigation of the constancy of the specific characters and the sexual peculiarities are highly interesting and form the most important feature of the work. In *Cambarus*, which includes all the species east of the Rocky Mts., the author has found that the first abdominal legs of the male present great and very constant specific differences, similar to those discovered in *Callinectes* by Ordway, and to those in some species of *Achelotis* and *Cardiosoma*. In this same genus two forms of males are described,—ordinary fully developed in-

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* This Journal, II, vol. l, p. 292, Sept., 1870.

dividuals, and a second form in which the individuals retain many of the features of the young and are supposed to be sterile. While the second form of males was found in every species of *Cambarus* of which any number of specimens were examined, it was found in none of the species of *Astacus*. This important discovery of dimorphism in the males of *Cambarus* is accredited to Prof. Agassiz. It is mentioned that perhaps the "fact of the existence in the Crustacea of two forms, one always sterile, is not unique," and a short account of dimorphism in other Crustacea and in insects is given. Among the decapods, the author notices the occurrence of sterile females in "*Lupa* and *Callinectes*," and states that he has "found similar females with a narrower triangular abdomen in some other genera of *Brachyura*." The occurrence of dimorphic sterile females is much more common among the *Brachyura* than this would imply. DeHaan mentions and figures such forms in several species of Portunids, and the writer has noticed them in *Neptunus*, *Achelоüs*, *Epilobocera*, and *Pinnotheres*. In all these cases the abdominal appendages are more or less rudimentary and not well adapted for the attachment of eggs.

Thirty-two species of *Cambarus* and six of *Astacus* are described, and eleven species, all *Cambari* are new. The description of the species is followed by an extended account of their geographical distribution. The author remarks on the absence of crawfish in central and eastern New England and the eastern portion of British America, and does not seem to have been aware of their occurrence in the St. Johns and Aroostook rivers.*

The eleven plates contain figures of the first abdominal legs of the male and some other parts of nearly all the species, from the author's drawings, and beautifully executed figures of the entire animals of eight species. S. I. S.

5. *Preliminary Report on the Crustacea dredged in the Gulf Stream in the Straits of Florida;* by L. F. DE POURTALES, Assist. U. S. Coast Survey. PART I, *Brachyura;* prepared by Dr. WILLIAM STIMPSON. Bulletin of the Museum of Comp. Zool., vol. ii, No. 2. 52 pp. Cambridge, Dec., 1870.—In this important paper, Dr. Stimpson gives a full list of the Brachyura collected by the Coast Survey dredging expeditions of 1867–8–9. 81 species, representing 47 genera, are mentioned, and 52 of the species and 19 of the genera are described as new. More than half the species belong to the Maioidea, while the Ocypodoidea are represented by only two species, both of them belonging to the Carcinoplacidæ. Only a small proportion of the species are from great depths, and the number of new forms seems largely due to the thorough exploration of the shallower waters. But 15 species are recorded as coming from below 100 fathoms, and of these 11 are Maioids, and the other 4 are Cancroids—a *Pilumnus*, 2 species of *Bathynectes* (a new genus allied to *Portunus*) and a species of *Achelоüs*. The

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* Reports on the Natural History and Geology of Maine. In the Museum of Yale College, there are specimens of *Cambarus propinquus* from Montreal and from Madison, Wisc.

greatest depth at which any of the species were found is 150 fathoms; and it is quite remarkable that the only species from that depth were *Portunidæ*—one of the species of *Bathynectes* and the *Acheloüs*. S. I. S.

6. *On the Mineral Constituents of Meteorites;* by N. S. MASKELYNE, M.A., Prof. Min. Oxford, and Brit. Mus. (Trans. Roy. Soc., 1870).—Mr. Maskelyne takes up in this paper the analysis of the Busti aërolite of 1852. He finds in it the compound, mono-sulphide of calcium, in small spherules of pale chestnut-brown color, and transparent when pure, to which he gave the name *Oldhamite* in 1862; and minute golden-yellow octahedrons (isometric) named *Osbornite.* The amount of the latter obtained for analysis was too small for completed results; but led to the conclusion that it contains sulphur, calcium and some titanium-like metal, not titanium or zirconium, with a trace of iron. It is infusible, and not acted on by boiling nitric acid, and, heated in a current of dry oxygen, it undergoes only an external oxidation. Mr. Maskelyne calls attention to observations of Prof. Mallett on a gold-yellow incrustation obtained by heating zirconium with lime and aluminum, contained in this Journal, II, xxviii, 346.

The other constitutents of the aërolite were a magnesian enstatite the main part, augite, schreibersite, nickeliferous iron, and a very small proportion of troilite (FeS) and chromite. The augite is a magnesia-lime augite.

The Manegaum meteorite, which fell in 1843, was found by Mr. Maskelyne to consist *of a single silicate, and that enstatite;* the enstatite is a highly ferriferous variety, containing

$$\ddot{\mathrm{Si}}\ 53{\cdot}63,\ \dot{\mathrm{F}}\mathrm{e}\ 20{\cdot}48,\ \dot{\mathrm{M}}\mathrm{g}\ 23{\cdot}32,\ \dot{\mathrm{C}}\mathrm{a}\ 1{\cdot}49,\ \dot{\mathrm{F}}\mathrm{e}\ \overset{\dots}{\bar{\mathrm{C}}}\mathrm{r}\ 1{\cdot}03 = 99{\cdot}95.$$

This meteorite contains only a minute amount of meteoric iron.

The investigations show that the flocculent opaque white mineral seen in the microscopic sections of many meteorites is often, if not always, enstatite.

7. *Fossil Mammals of the Rocky Mountains collected by Dr. Hayden;* Dr. LEIDY, (Proc. Acad. Nat. Sci. of Philadelphia, Oct. 4–18).—Dr. Leidy here brings out many new facts with regard to the Tertiary Mammalian life of this Continent.

On the Sweet Water river, eighteen miles west of Devil's Gate, Wyoming Terr., the bones are mostly of a species of Merycochœrus, smaller than *M. proprius;* but with these there are remains of an equine animal, perhaps a *Hipparion*, and of *Canis vafer* and *Merycodus necatus*, species first described from the Niobrara.

From Fort Bridger there is a molar of apparently a small species of *Lophiodon;* part of a lower jaw of a pachyderm, which is named provisionally *Hyopsodus paulus;* an animal allied to *Chalicotherium* and *Titanotherium*, which Dr. Leidy named *Palæosyops paludosus*, (other specimens of which have been received from Henry's Fork of Green river, Wyoming; a species related to the Peccary, named *Microsus cuspidatus*; and one related to the Raccoon, named *Notharctus tenebrosus.*

8. *Fossil Mammals from Oregon;* J. LEIDY, (ib.).—The specimens were from Rev. Thos. Condon of Dalles City, Oregon. Dr.

Leidy observes that the greater number of specimens belong to a species of *Oreodon* larger than any before described, and as large as *Merycochœrus proprius*, with which species it may be identical. He names it *Oreodon superbus.* There are also a few fragments of jaws of *O. Culbertsoni*, *Agriochœrus antiquus*, *Leptomeryx Evansi*, *Anchitherium Bairdi.* The above are from "the Big-bottom of the John Day river." From Bridge Creek, a tributary of the John Day, there are remains of *Lophiodon occidentalis?*, an animal about the size of *Tapirus terrestris*, two species of Rhinoceros, one the *R. occidentalis?*, another *R. hesperius?*, *Elotherium superbum?*, a Peccary as large as *Dicotyles torquatus*, an *Anchitherium* larger than *A. Bairdi*, called *A. Cordoni.*

9. *Cretaceous and Tertiary Reptilia and Fishes.*—In the Proceedings of the American Philosophical Society, Prof. Cope describes 4 species of Saurocephalus from the Cretaceous of Kansas, 1 of Icthyodectes (n. gen. near Saurocephalus) same locality, and several new fishes, chiefly Cyprinidæ, from a freshwater Tertiary deposit in Idaho discovered by Capt. C. King. Dr. Leidy has observed among mammalian remains from the same beds, portions of *Mastodon mirificus* and *Equus excelsus*, species that occur in the Niobrara beds and which have been referred to the Pliocene. The Mollusks of the beds, according to Meek, are different specifically, and some generically, from all others hitherto described from the West. Prof. Cope, in view of the characters of the fishes, says that there is great probability of the beds being later than Miocene, and nothing to conflict with their being Pliocene.

10. *Geological Survey of Ohio.* Part I, Report of Progress in 1869, by J. S. Newberry, Chief Geologist. Part II, Report of Progress in the Second District, by E. B. Andrews, Assistant Geologist. Part III, Report on Geology of Montgomery County, by Edward Orton, Assistant Geologist. 164 pp. 8vo, with a colored geological map of the state, and sections. Columbus, 1870.—Much interest attaches to the Geological Survey of Ohio, because of the position of the state between New York and the states of the Mississippi basin. The work already done by Dr. Newberry and his able associates has thrown much light on the connection between the two regions, besides adding many new facts with regard to the coal and coal beds of the state. We propose to notice the results at some length in our next number.

11. *Gas Wells in Ohio.*—Dr. Newberry states in a paper in the American Chemist for December, that the two gas wells bored by Mr. P. Neff in the valley of the Kokosing have been flowing gas in apparently undiminished volume to the present time. Other wells have since been opened. Near Millwood where the rocks are much disturbed, two wells give out oil, one three and the other eight gallons per day; two or three miles below, near the mouth of the Kokosing, the augur, on reaching the depth of 600 feet, struck into vertical crevices and sunk several feet without resistance; and from two crevices a volume of carburetted hydrogen issued which was unparalleled in all the oil explorations made in the country; the wells give out salt water intermittently, throw-

ing it to a height of over one hundred feet. The gas of one of the wells, lighted at the end of a pipe two inches in the clear set in the well head, produced a jet of flame 20 feet long and as large as a hogshead. By fixing a stop-cock in the pipe the gas was made to accumulate until, measured by a steam gauge, the pressure amounted to 180 pounds to the square inch. The gas appears to be pure and the volume sufficient to light a large city.

12. *Linnæan Hypothesis of the Derivation of species.*—Ludwig von Hohenbühel-Heufler contributes an article to the *Botanische Zeitung* for Sept. 9, 1870, in which he claims for Linnæus the origination of *the* theory of the derivation of species,—founding the claim upon the paragraphs which Linnæus appended to the sixth edition of his *Genera Plantarum*, published in 1764, viz:

1. "Creator T. O. in primordio vestiit Vegetabile *Medullare* principiis constitutivis diversi *Corticalis*, unde tot difformia individua, quot *Ordines* Naturales, prognata.
2. *Classicas* has (1) plantas Omnipotens miscuit inter se, unde tot *Genera* ordinum, quot inde plantæ.
3. *Genericas* has (2) miscuit Natura, unde tot *species* congeneres, quot hodie existunt.
4. *Species* has (3) miscuit Casus, unde totidem, quot passim occurrunt, *Varietates*.
5. Suadent hæc (1–4) *Creatoris* leges a simplicibus ad composita. *Naturæ* leges generationis in hybridis. *Hominis* leges ex observatis a posteriori.

Whatever meaning be put upon these somewhat enigmatical propositions, they certainly show that Linnæus (as a naturalist of his turn of mind was not unlikely to do) had thought of a derivative origin of species as not improbable, and had formed some idea of an hypothesis concerning it,—perhaps as definite as his idea of natural orders,—a problem he could suggest rather than solve. And it is interesting to note the scale of operating powers,—Chance sufficing for the production of varieties, Nature for genera, the Omnipotent directly for the mightier work of producing orders.

In a subsequent number of the *Bot. Zeitung*, that for November 18, the veteran senior editor, Von Mohl, takes up the subject. and maintains, with much reason, that the theory of Linnæus, whatever it amounts to, has no special likeness to the modern "Descendenztheorie," in any important particular. For, he concludes that the "a simplicibus ad composita" of Linnæus did not involve the idea of a rise in organization from a plant or plants of lowest to those of higher grade, nor did he imagine the diversification to have been a consequence of the inherent powers of the plants themselves, or to be still proceeding, so that the present is any representation of the past. But he thought it necessary to admit a direct interference of the Creator twice, once in the origination of plants representing the natural orders, and then in the supernatural diversification of these by *crossing*, to produce the genera; and only the genera are supposed to have mingled by crossing in virtue of the natural laws of propagation, so as to result in the formation of the existing species, which species Mohl thinks, were regarded by Linnæus as unchangeable since their first appearance, excepting the mere accident of variation by hybridation, etc. So that Linnæus might with full consistency retain his well known definition or axiom: "Species tot sunt, quot diversas et constantes formas in hoc globo prodixit Infinitum Ens," etc., and so this axiom holds its place in the Ratio Operis of the same volume to which, at the close, this hypothesis of the diversification of species is appended. But we can hardly suppose that a philosopher like Linnæus would attribute this diversification as to species to natural causes, and then imagine that existent natural causes had ceased to operate; and he would certainly have seen that the continued crossing of the species of a genus would soon have resulted in the total obscuration of species. If he thought at all of harmonizing his practical definition with his suggested hypothesis, he probably regarded species as having only a relative stability, so as to be essentially unchanged for any period within human ken, whatever their origin or progress in the long run.

To throw some light upon Linnæus's enunciation, which appears so obscure, of an essential *medullary substance*, invested with an accessory *cortical substance* in all plants, Von Mohl makes a long extract from the dissertation of Linnæus upon Generatio Ambigena, published in the 6th vol. of the Amœnitates Academicæ,—a curious speculation which would take some time to explain, one to which Linnæus elsewhere refers, especially in explaining the nature of the blossom, and in which doubtless, as Mohl supposes, is to be found the key to the understanding of his derivative hypothesis. A. G.

13. *Monograph of the Ranunculaceæ of the Dominion of Canada;* by Prof. Geo. Lawson, Dalhousie College, Halifax, contributed to the Canadian Naturalist.—A full account of this family, with ample details as to geographical distribution, etc. In the character of the tribes the position of the seed is omitted, probably as too difficult for popular apprehension, though it is really easy enough. *Pulsatilla* is kept as a genus, but not *Atragene*, yet the two would seem to stand or fall together, and *Hepatica* is reduced to *Anemone*. Of the latter genus, the name *A. dichotoma* replaces *A. Pennsylvanica*, "because the latter suggests erroneous ideas of the plant's distribution." We can adduce a far better reason, viz: that it is of almost twenty years later date. In the admission of *Thalictrum clavatum* as a Canadian plant, Prof. Lawson shows that he has not followed up the history of this species, nor noted that in the Manual its northern limit is said to be S. Virginia. He should substitute the name *T. sparsiflorum*, and see, for authority, *Plantæ Wrightianæ*, ii, p. 8, and this Journal, xlii, p. 17, as well as 33, new series, in the account of Dr. Parry's collection. The first and last of these references will throw light also upon the notable peculiarity mentioned in the geographical distribution of *Delphinium exaltatum*, which species, if at all Canadian, is likely to inhabit only the most southern latitude.

A. G.

14. *Œrsted on characters furnished by the styles in Cupuliferæ and Juglandeæ, etc.*—In the Copenhagen *Videnskabelige Meddelelser* a few years ago Prof. Œrsted very fully worked out and displayed the high systematic importance of the form of the styles and stigmas in *Quercus* and the other *Cupuliferæ.* To the same publication, for the year 1869, he has contributed a brief article on the same subject in relation to the Californian Holly Oak (*Quercus agrifolia*), in Danish, of which at the close of the volume he has kindly given a French translation. He shows that this oak, with the port of *Q. Ilex*, has the styles and calyx as well as the ovules of the mainly Asiatic subgenus *Erythrobalanus*, in which he forms for it a separate section.

To the volume for 1870, Œrsted contributes an analogous note upon *Juglandeæ*, in which, by the way, he points out the fact that *Pterocarya* differs from *Juglans* and *Carya* in having foliaceous four-parted cotyledons which rise out of ground in germination; and he proceeds to show that his *Oreonumoa*, from Central America, which in the Prodromus had been made a section of the Asiatic genus *Engelhardtia*, is remarkably distinguished by its styles and less so by its embryo. Both papers conclude with remarks upon the geographical distribution of these genera, etc., as related to recent geological changes. Noting that *Juglans*, *Carya*, and *Engelhardtia* were all three well represented in Europe during the Miocene period, he infers that America was thence supplied with *Juglans* and *Carya* by way of the west, and with the representative of *Engelhardtia* by the east. We think that all the known facts conspire to show that both came by the east and north. In the structure of the styles of *Quercus agrifolia* Œrsted detects an oriental origin; and he speculates suggestively upon the Asiatic elements in the Californian flora (which we think are few) and upon what he calls its insular character, meaning by this, probably, only its marked distinction from the eastern N. American flora. And he appears to attribute this to the Sierra Nevada, which he terms the *maritime* Alps of California. But a different and more efficient way of separation may readily be suggested. A. G.

III. Miscellaneous Scientific Intelligence.

1. *Meteorological Observations on Mt. Washington.*—The meteorological observatory, as it may be called, on Mt. Washington, which Prof. C. Hitchcock, the head of the Geological Survey of New Hampshire, and Prof. J. H. Huntington have been the means of establishing, has for its observers Prof. Huntington, Mr. S. A. Nelson of Georgetown, Mass., and Sergeant Theodore Smith. The latter is also telegrapher, and was appointed to the station by General Myer, head of the "Bureau of Telegrams and Reports for the Benefit of Commerce," recently established by Congress. In addition, Messrs. A. F. Clough and H. A. Kimball are the photographers. Prof. C. H. Hitchcock, at Hanover, has telegraphic connection with the summit, and occasionally joins the observers.

Gen. Myer ordered the laying of the telegraphic wire to the summit, so that a daily statement of the observations might be sent to Washington and to the rest of the country. The house occupied by the observers is the depot of the Mt. Washington railroad. The party has two barometers, thermometers, a hydrometer, Robinson's self-registering anemometer, and an anemoscope. Three daily telegraphic reports are sent out, two to the Bureau of Telegrams at Washington, and one to the New England Associated Press, Boston. The party give their time and labor without remuneration. The expenses, apart from those of the agent of the Bureau of Telegrams, have been assumed by Prof. Hitchcock, he depending on the public for its return. He states in a letter dated December 31st, that two hundred dollars more are needed to carry them through the season. Part of the expenses come from the necessity of keeping a watch for the telegraph wire in the windy region between Littlefield and the mountains.

2. *Unusual exhibition of halos.*—On the morning of Dec. 21, 1870, there was observed at Galesburg, Illinois, an unusual exhibition of halos. The phenomenon began when the sun rose, and continued till nearly noon, though after ten o'clock nothing was seen but the common halo of 22° radius. About 45 minutes after sunrise, there was seen the halo of 22° radius; that of 46° radius; a parhelic circle through the sun, parallel to the horizon; two parhelia on each side of the sun near the intersection of the parhelic circle with the two halos; a contact arch near the highest point of each of the halos; and a vertical column passing through the sun. All these phenomena are represented by figures in Loomis's Treatise on Meteorology, pages 216–219. Besides these appearances there were also noticed lines of illumination nearly vertical, but somewhat concave toward the sun, about five or six degrees in length, touching the circle of 46° radius at the points where it was intersected by the parhelic circle. These arcs are of unusual occurrence. They are, however, noticed by Prof. Bravais in his Memoir on Halos in the Journal de l'Ecole Polytechnique, t. 18, p. 112.

The temperature at the time of these halos was about zero, and the air was full of frost, driven sometimes in light clouds before a brisk N.W. breeze. For the above information we are indebted to a letter from Prof. M. L. Comstock of Knox College.

3. *Head Waters of the Amazon.—Observations on the Geography and Archæology of Peru;* by E. G. SQUIER. 28 pp. 8vo. (Read before the Amer. Geogr. Soc., Feb., 1870).—In the course of this interesting Memoir, Mr. Squier discusses the question whether the river Marañon or the Ucayali, (the two rivers which unite to form the Amazon), should be considered the main head of the Amazon. He observes that the Ucayali exceeds the Marañon by several hundreds of miles, whether its longest branch be the Urubamba or Vilcamayo rising at the lake of La Raza, or the Apurimac rising in the department of Arequipa. As regards volume, he cites Dr. Tavara, a member of the Hydrographic Commission of 1868, under the Peruvian government, who says

that the Marañon both in length and volume is inferior to the Ucayali, and it therefore "leaves the latter to bear without dispute the title of Rio Madre del Amazonas." The Ucayali is navigable from the junction of the two rivers, the Urubamba (or Vilcamayo) and the Tambo which join to form it, down to the Amazon, a distance of 772 miles; and the Urubamba is navigable for small vessels for 216 miles, or 220 miles from Cuzco, the capital of the most populous department of Peru, and that with which communication with the Amazon would be of the highest importance.

4. *Solar Eclipse.*—No information has yet been received (Jan. 16th) with regard to the observations on the recent solar eclipse beyond the general intelligence that the observers had good weather in Spain, and only moderately good in Sicily; and the fact that the Psyche, having the Sicilian party from England on board, foundered on a sunken rock off Catania, but without loss of hands or of scientific instruments.

5. *Murchison* was disabled near the close of November by a stroke of paralysis. According to the latest reports he will soon be at work again.

6. *Prof. Balfour Stewart* was among the sufferers by the collision on the London and Northwestern Railway, on the 26th of November. He is reported as gaining as rapidly as could be expected, considering the nature of his injuries.

OBITUARY.

G. BISCHOF, the author of the great work on Chemical Geology and of various researches on related subjects, died early in Deember last, at Bonn.

Wm. CHAUVENET, author of several mathematical works of high merit, and for some years Chancellor of the University of St. Louis, died at St. Paul, Minn., Dec. 13, 1870, aged 51.

IV. MISCELLANEOUS BIBLIOGRAPHY.

1. *The Journal of the Franklin Institute.* Editors, Drs. MORTON and WAHL. Philadelphia, Pa.—Our esteemed contemporary enters with its current number upon its 46th year; and we are pleased to learn, with every prospect for prosperity and continued usefulness.

Devoted strictly to Mechanical and Physical Science, it has long and ably held an honored position among American journals and is the favorite organ of our practical scientists.

As the written tradition of the oldest Mechanics' Institute in America, it is well entitled, by this time, to wear grey hairs,—yet no such grave characteristics are visible to us; and if it is literally to "renew its youth" for another half century, the hands in which we now find it are well qualified to inaugurate the happy era.

2. *The Malay Archipelago: the Land of the Orang-utan and the Bird of Paradise. A Narrative of Travel, with Studies of Man and Nature;* by ALFRED RUSSELL WALLACE, author of "Travels on the Amazon and Rio Negro." "Palm Trees of the Amazon," etc. 638 pp. 12mo. New York, 1869. (Haperr &

Bros.)—Although it is over a year since this work was published, it deserves mention here. Mr. Wallace's explorations were undertaken for the purpose of collecting specimens in Natural History. His work gives much interesting information on the customs of the people he visited, but is chiefly important to science, on account of its notes on the habits, peculiarities and geographical distribution of the animal and vegetable life of the various islands. As the idea of "Natural selection" had already come to him, he aims to point out the bearings of the various facts on the question of variation, and thereby on the origin of species. All will not accept his conclusions, which seem sometimes forced, but they cannot fail to read with interest and profit the results of his observations, although given with an excess of personal detail. The volume contains a map of the East Indies, and many excellent illustrations.

3. *Adventures of a Young Naturalist;* by L. BIART, edited and adapted by Parker Gillmore, author of "All Round the World," etc. 492 pp. 12mo, with 117 illustrations. New York, 1871, (Harper & Brothers.)—Our School system will not be complete in its arrangement of studies until children are made to enter upon some simple course in Natural History—teaching them how and what to see in this objective world,—from the time they are ten or eleven years of age. It is well for them, that while the schools are thus defective, they are partly supplied with the means of such instruction in the "Young" literature of the day; and one of the best books for the purpose is the Adventures of a Young Naturalist. The region of these adventures was Mexico. Facts about its prominent trees, flowers, and animal life, and the physical phenomena that appear by the way are introduced as a part of the adventures, and usually in a manner that adds interest to the story. The volume is illustrated by a multitude of engravings, which exhibit, with wonderful exactness and artistic effect, the forest scenes of the tropics. We should like to change the page on aërolites and some other paragraphs. But in general the book is well suited to its purpose.

4. *The Rob Roy on the Jordan, Nile, Red Sea, etc.;* by J. MACGREGOR. 464 pp. 12mo, with maps and illustrations. New York, 1870. (Harper & Brothers).—This admirable book of canoe travel by a man of resource and culture, and of sympathy with all that is good and beautiful, is not without special scientific interest, as it contains excellent descriptions of natural scenery of rivers and mountains, treats of the present distribution of the crocodile of the Nile, and gives the first account published of the head-waters of the Jordan. [2, 3, 4 are originally English publications.]

United States Geological Exploration of the Fortieth Parallel: Clarence King, Geologist in charge. Vol III. Mining Industry by James D. Hague, with geological contributions by Clarence King. 648 pp. 4to, illustrated by 37 plates and an accompanying Atlas of 14 colored Imperial folio plates. Washington, (Government Printing Office.) 1870.

Report on the Geological Survey of the State of Iowa, made to the thirtieth General Assembly, Jan. 7, 1870, containing results of examinations and observations made within the years 1866-1869; by Charles A. White M.D. Vol. I. 392 pp. royal 8vo with maps, views, and sections. Des Moines, 1870. Geological Corps, C. A. WHITE, State Geologist, O. H. ST. JOHN, Assistant, R. EMERY, Chemist.

APPENDIX.

Letter to the Editors from Prof. B. A. Gould, *dated Cordoba* (*Cordova*), *November* 9, 1870.

I will begin to-day to fulfil my promise of writing to you from time to time of the progress of our Argentine Observatory, or rather of the preparations for its organization.

Leaving New York on the 28th of May, and arriving in England after 11 days, just six weeks were available for a hurried visit to London, Paris, and some of the German cities, where instruments were constructing, or books were to be obtained. Fortunately all was then peaceful and happy, and the sudden outburst of war did not take place until we were in England again, and on the point of re-embarkation. The greatest interest and sympathy were manifested by all the astronomers whom I met; and many of them gave expression to their good-will in a very practical and tangible manner, by gifts of serviceable books and by essential assistance.

On July 20, we left Liverpool in a steamship bearing the auspicious name of "Tycho Brahe," and landed on August 23d in Buenos Aires, where the cordiality of our reception could scarcely be surpassed. The officers of the National Government have afforded every courtesy and assistance possible, while the citizens seem to feel a sincere and most intelligent interest in our undertaking, and have extended to us a most friendly and gratifying welcome. Only two or three days previous to my arrival, an appropriation had been passed by the National Congress for the acquisition of additional instruments and books; but on a subsequent reconsideration a further amount was added for the purpose of completing and extending the building, which had been but partially provided for.

While crossing the tropics, I was much impressed by the luminosity of the background of the heavens, by night. This afforded a light not inferior to that of the sky when the moon is at her quarter,—reducing the apparent brilliancy of the stars, and often rendering it difficult to recognize the outline of prominent constellations. I have an indistinct remembrance of reading some similar remark, in Humboldt's personal narrative, I think; but of course I have here no means of refreshing my memory. This brightness was not dissimilar to that of the interior of an auroral arch. Can it be that this phenomenon stands in some relation to zodiacal light? That this latter is a terrestrial appendage and not a solar one, I have long regarded as demonstrated. This atmospheric or superatmospheric brightness first attracted my attention when we had reached the latitude of 30° N., and was much fainter soon after we had crossed the equator. The lenticular outline of the zodiacal light was not visible in the west after sunset on these occasions; indeed, the general brightness of the sky was quite as great as I have ever seen that of the zodiacal light itself.

My own family reached Cordoba on the night of September 8, and I lost no time in selecting a site for the Observatory. The

Provincial Government undertook to purchase and present to the Observatory a piece of land 250 varas ($216{\cdot}9^{m}$) square, and within four days the position was chosen and the preliminary steps were taken for the acquisition of the ground. At present the foundations, both for the buildings and the piers of the instruments, are essentially completed, and there is no doubt in my own mind that the mason work for the whole building will be completed at the close of November.

Cordoba is situated only about ten miles east of the base of the Sierra, and occupies an eroded basin, about 1¼ miles in width, along the north side of which runs the Rio Primero, which, rising in the Sierra, discharges its waters into a salt lake some eighty miles farther eastward. It is so easily fordable, except in the rainy season, that no bridge has been constructed across it until this present month, but an iron one has now been erected by the National Government. The valley of the river, which is here expanded into a basin, although much contracted both above and below the town, is bounded by walls of sandy clay, or rather by what would be walls were it not for their very broken and irregular outline, caused by the wash of the torrents, which pour down into the hollow after every rain, leaving ravines or gullies of from ten to forty feet deep, which extend far into the plain above,—forming a miniature coast indented by fiords, like the shores of Norway and Scotland. The city itself rests on a bed of firm granitic sand, which drifts with the wind; but the dustiness of the unwatered plains of fine powdered clay on the pampa above cannot be described. The *barranca*, or bank, varies in height from eight to twenty-six meters, and the land then rises with a gentle slope southward to the divide between the rivers Primero and Segundo, and northward similarly for a considerable distance. At a distance of two miles from the city, north or south, only the summits of the many church-towers are visible, springing apparently out of the ground. The elevation of the town above the sea-level is variously stated, but cannot be far from four hundred meters; the whole pampa having a slight inclination from the mountains to the sea.

Of course it was out of the question to place the Observatory in the hollow, for want of a proper horizon, as well as on account of the numerous obstructions from houses or trees. Upon the barranca, a better foundation is likewise afforded upon the *tosca*, or hard clay, which alternates with sand in successive strata. The disadvantages consist in the distance from other dwellings, and in the total want of water, which can only be obtained from the river, or from wells of some seventy meters or more in depth; —while the impalpable and all pervading dust will inevitably render the instruments valueless, unless an abundant vegetation be maintained in the immediate vicinity of the building. For this, means will doubtless be provided in some way, inasmuch as the Minister, and all the officers of Government who have to do with the affairs of the Observatory, are evidently anxious to do every thing in their power to promote its success.

The four assistants arrived Sept. 26, and on Oct. 17, came the first instalments of material for the building. The plans had been excellently worked out by Messrs. Harris and Ryder of Boston, who had also superintended the construction of those portions which consist of iron,—such as the roof, floors, stairways, revolving dome, and machinery for opening and closing the shutters,—all in a manner which reflects on them the highest credit. But to my deep regret and mortification, the carpentry had been shipped in such an improper manner, and the bills of lading so loosely made out, that the materials have arrived in an unsatisfactory state; much being missing and more badly broken, while we have no legal hold on the ship. When the parts are assorted for putting together, which will probably be in a month, I hope the state of affairs will prove better than present indications promise.

The small portable transit instrument of the Coast Survey has been in use for the past week under a little hut of bricks and mud constructed for the purpose, and the Smithsonian zenith-telescope is just put in place. From such means of judgment as I have yet obtained, I suppose the geographical position to be not far from 31° 24′ 40″ south latitude and 0^h 52^m 34″ east from Washington.

The meteorological relations of this region are evidently very peculiar, and I deeply regret my want of apparatus for their proper investigation without trenching upon the means and energies requisite for our legitimate astronomical work. In Buenos Aires the winter is a rainy season, while the summers are dry. Here, at a distance of 500 miles, the reverse holds good; the winters being absolutely rainless, but the summers subject to frequent and very violent rains. A sharp shower of half an hour on Sept. 29th, was the first rain of the season, none having fallen up to that time since the beginning of May. Now we have a shower every three or four days, always violent and copious, but not generally continuing for more than an hour. Later in the summer we are told that they will be yet more impetuous and of longer duration; but a continued storm of half a day or more is said to be unknown here. Thunder and lighting are the unfailing attendants of these rains, and I have never seen more splendid exhibitions of atmospheric electricity than have accompanied every one of the eight or ten which have occurred during the past month. The volume of water which falls on these occasions is immense. The river often rises many feet in a single hour, receding afterward nearly as rapidly. Part of the town is traversed by what is called the cañada, the bed of a water-course some 6 or 7 meters in breadth, which discharges into the river, and is bordered by steep banks until it reaches the basin in which the town is situated. This is usually dry, in fact I have never seen it otherwise, although I am residing within 50 yards of it, and cross it many times a day. But during, and immediately after, one of these violent rains, it becomes the channel of a torrent, and has been known to rise to the height of 4 meters in two hours. It is fed by no spring, and merely brings down the surface drainage of a few miles of pampa; yet but for a strong dike built by the Jesuits in 1671, the city would be subject to severe inundations. Indeed a flood from this cañada did destroy a large part of the town in 1623. The whole line of the barranca is intersected by ravines similar in character to this cañada, and it is these which produce the broken jagged outline of which I have spoken. I have found it impossible to select a fitting place for the observatory, where the grounds could be unbroken by these gullies, and care will be needful to prevent the descent to a lower level of much of the soil which has been given us.

The wind is very rarely from the east, and I am informed that it has never been known to be due west; a circumstance doubtless attributable in great part to the barrier presented by the magnificent Sierra west of the city. The winters are very chilly, even snow being not infrequent, although ice does not form. Even now while roses, cactuses, cassias and white lilies are in full bloom, the young peaches of half their full size, and the grapes well formed, —the mornings are uncomfortably chilly, and no one thinks of wearing other clothes than woolen. Yet before the sun is an hour high, and until he has gone down in the west, his beams are simply intolerable. The foreigner who goes about or exercises in the sunshine between 12 and 2, is sure to rue it, and the natives never commit such an indiscretion. The astronomer, whose exposure is by night, finds himself for once at a vantage in the fiery Argentine summer. Yet the air is not so hot as the torrid climate would suggest; and the nights even in midsummer are cool.

The dryness of the air has impressed me quite as much as any other climatic peculiarity. A bowl of water left uncovered in the morning is dry at night; ink vanishes from the inkstand and becomes thick almost by magic; the bodies of animals, left exposed, dry up instead of decomposing; and at other times than during, or immediately after a rain, neither active exercise nor exposure to the sun's rays cause a perceptible perspiration.

We are suffering no small embarrassment from the non-arrival of our books and instruments from Germany. The Meridian circle, clocks, chronometer, photometer, etc., were all on board ship at Hamburg, when the war was declared, and up to the last advices, although the blockade of the Elbe had been raised, no vessel for the River La Plata had ventured to leave port. Should another month pass without their arrival it would be a serious drawback to us. Meantime there is plenty of work to be done in superintending the building, and making the numerous preliminary calculations for places of standard stars, tables of reduction, etc. Should the meridian-circle be long delayed, the time might be well employed in making such a Uranometry for the southern sky as the absence of a photometer will allow,—on the same plan as Argelander's, and as my unpublished northern one, made at Albany in 1858.

The temporary embarrassments of the Government-treasury, occasioned by the serious and destructive insurrection in Entre Rios, may slightly retard our progress, or at least render it less easy for the necessary means to be provided, especially since the carpentry has arrived in so unfortunate a condition; but that cordial desire to facilitate our work, which clearly animates all parties here, will doubtless reduce difficulties of this sort to a minimum while they continue, and render their duration as brief as may be.

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ART. XXIV.—*On the Discovery of actual Glaciers on the Mountains of the Pacific Slope;* by CLARENCE KING, U. S. Geologist.

WESTERN explorers have usually confined their labors to the more accessible altitudes; indeed it is only within the last ten years that the higher portions of the great West have been studied. One remarkable feature of the extreme elevations is the absence of glaciers. Wide areas of mountains whose average altitude and configuration are equivalent to the glacier-bearing mountains of Switzerland have been found to be covered here and there by deep fields of perpetual snow, similar in character to the *névé* of the Alps. The whole topography of the loftier Cordillera within the United States has been modified by glaciers now extinct: vast moraines flank the higher gorges; accumulations of gravels and sands, erratics, *roches montonnées*, and the finest possible instances of polished rock abound wherever a considerable mountain mass is lifted above nine thousand feet. It is almost startling to observe the freshness of these indications. Travel where one will in the high Sierras or in the more elevated regions of the Rocky Mountains, he seems to be treading the pathway of a glacier of yesterday. A future study will, without doubt, clear up the entire chronological relations of the ice occupation of these ranges. The studies of Professor Whitney and his corps in the heights of the Sierra Nevada have developed a series of extinct glaciers equaling in all respects the former grandeur of the Alpine system; yet with the exception of one or two rudimentary masses of ice, nothing is left in the Sierras but the fields of perpetual *névé* snow. Very remarkable in depth and area as these are, they are not sufficiently extended, nor is there enough winter accumulation of snow, to start a glacier movement. Singularly too, the heights of Colorado prove to be even less snowy than the Sierras. The *névé* masses are less, and they waste much more during the dry season. The Wind River, Wahsatch and Uintah ranges have been examined by the writer, and although the extent of lofty peaks is very great, they are even less snowy than the heights of the Laramie range in Colorado. A comparison of the average annual temperatures of the Cordillera north of latitude 36° clearly shows that the climate is not too warm for the existence of glacier masses, and that the small precipitation of snow is due chiefly to the lack of moisture in the air. This entire region is swept by an almost invariable west wind, whose lower strata have been deprived of their moisture by the warm ascending currents of the valleys, and, although the peaks of the mountains are lifted into this wind, the actual amount of moisture is too small to create a great piling up of *névé*. Accordingly the summit region is characterized by the absence of glaciers and a tendency of the entire flora to ascend into higher altitudes than at corresponding Alpine stations. A single point lifted to a great height is not sufficient to form a great condenser. A widely elevated region is necessary for the creation of great local storm systems; the two parts of the Cordillera, therefore, where we should most naturally look for glaciers are the Mount Whitney region in the Sierras of California, and the high group west of Denver. Professor Whitney, in his description of the former, calls particular attention to their absence. The writer was one of those who made the exploration of this region, and was as much impressed as any one with this remarkable lack.

In early September, 1870, with a small detachment of "the U. S. Geological Exploration of the 40th Parallel," acting under the orders of Maj. Gen. Humphreys, I visited Mount Shasta in northern California, for the purpose of making a detailed survey of the lava systems which flow eastward from that peak, and connect themselves with the basalt regions of the Nevada Desert. On September 11th, we climbed to the top of the lesser Shasta, a conical secondary crater jutting out from the main mass of the mountain on its northwest side. The party consisted of Mr. S. F. Emmons, Mr. F. A. Clark, Mr. A. B. Clark, and Mr. Sisson, the well-known mountaineer and guide of the region, and the writer. We carried our physical and topographical instruments, our fur beds, and provisions for four days. In the afternoon at about half past one o'clock we reached the rim of the cone, and looked down into a deep gorge lying between the secondary crater and the main mass of

Shasta, and saw directly beneath us a fine glacier, which started almost at the very crest of the main mountain, flowing toward us, and curving around the circular base of our cone. Its entire length in view was not less than three miles, its width opposite our station about four thousand feet, the surface here and there terribly broken in "cascades," and presenting all the characteristic features of similar glaciers elsewhere. The region of the terminal moraine was more extended than is usual in the Alps. The piles of rubbish superimposed upon the end of the ice indicated a much greater thickness of the glacier in former days. After finishing our observations upon the side crater, and spending a night upon the sharp edge of its rim, on the following morning we climbed over the divide to the main cone, and up to the extreme summit of Shasta, a point 14,440 feet above the sea level. From the crest I walked out to the northern edge of a prominent spur, and looked down upon the system of three considerable glaciers, the largest about four and a half miles in length, and two to three miles wide. On the next day we descended upon the *south* side of the cone, following the ordinary track by which earlier parties have made the climb. From the moment we left the summit we encountered less and less snow, and at no part of the journey were able to see a glacier. An east-and-west line divides the mountain into glacier-bearing and non-glacier-bearing halves. The ascent was formerly always made upon the south side where, as stated, there are no glaciers, and this is why able scientific observers like Professor Whitney and his party should have scaled the mountain without discovering their existence.

Before and after the ascent of Mount Shasta, a week was given to an examination of the southern half of the volcano. Since the earliest settlement of Strawberry and Shasta valleys, there has never been such a complete denudation. From June to November, the snow masses were less than they have ever been seen before. This favored very greatly our geological observations, and gave us an excellent opportunity to study the relics of the former great *névé*. We explored one after another all the cañons which, approximately following the radius of the cone, are carved to a greater or less depth into the lava-flows. From the secondary cone around to the eastern side of the main mass are only occasional fields of snow and ice—bodies of a thousand or two feet long, usually quite narrow and lying on the more shaded sides of the ravines. In nature and texture they are quite similar to the true glacier ice, possessing in all cases planes of stratification which indicate the pressure of the formerly overlying masses. There is little doubt that all the scattered snowfields, that, in the months of August and September, dapple the southern slopes, are the relics of glaciers. They are found in the region of the ancient *névé*, but extending downward into what was formerly the zone of movement.

Upon reaching the eastern side we found in a deep cañon a considerable glacier, having its origin in a broad *névé* which reaches to the very summit of the peak. The entire angle of this glacier can be hardly less than 28°. It is one series of cascades, the whole front of the ice being crevassed in the most interesting manner. Near the lower end, divided by a boss of lava, it forks into two distinct bodies, one ending in an abrupt rounded face no less than nine hundred feet in height. Below this the other branch extends down the cañon for a mile and a half, covered throughout almost this entire length with loads of stones which are constantly falling in showers from the cañon walls on either side. Indeed for a full mile the ice is only visible in occasional spots where cavities have been melted into its body and loads of stones have fallen in. From an archway under the end a considerable stream flows out, milky, like the water of the Swiss glacier streams, with suspended sand. Following around the eastern base of Shasta, we made our camps near the upper region of vegetation, where the forest and perpetual snow touch each other. A third glacier of somewhat greater extent than the one just described, was found upon the northeast slope of the mountain, and upon the north slope, one of much greater dimensions. The exploration of this latter proved of very great interest in more ways than one. Receiving the snows of the entire north slope of the cone, it falls in a great field, covering the slope of the mountain for a breadth of about three or four miles, reaching down the cañons between four and five miles, its lower edge dividing into a number of lesser ice-streams which occupy the beds of the cañons. This mass is sufficiently large to partake of the convexity of the cone, and, judging from the depth of the cañons upon the south and southeast slopes of the mountain, the thickness cannot be less than from eighteen to twenty-five hundred feet. It is crevassed in a series of immense chasms, some of them two thousand feet long by thirty and even fifty feet wide. In one or two places the whole surface is broken with concentric systems of fissures, and these are invaded by a set of radial breaks which shatter the ice into a confusion of immense blocks. Snow bridges similar to those in the Swiss glaciers are the only means of crossing these chasms, and lend a spice of danger to the whole examination. The region of the terminal moraines is quite unlike that of the Alps, a larger portion of the glacier itself being covered by loads of angular débris. The whole north face of the mountain is one great body of ice, interrupted by a few sharp lava ridges which project above its general level. The veins of blue ice, the planes of stratification, were distinctly observed, but neither *moulins* nor regular dirt-bands are present. Numerous streams, however, flow over the surface of the ice, but they happen to pour into crevasses which are at present quite wide.

One of the most interesting of all the features of the country was, however, the clearly defined moraines of the ancient and more widely extended glacier system. Nearly the whole topography of the lower part of the cone is modified by the deposition of glacial material. At an elevation of about eight thousand feet upon the southern or snowless side of the mountain, is a great plateau-like terrace, about twenty-five hundred or three thousand feet wide, extending around one half of the cone and composed wholly of moraine material. Besides these, long, straight, or slightly curved medial moraines jut from the mountain in all directions, not unfrequently descending into the valley for several miles. Our party spent six weeks in climbing all over the cone, studying the systems of lava flows, laying down the sheets of material as they are exposed upon the flanks and cañons of the snowless parts of the mountain; and in making a detailed examination of the glaciers, and a complete survey of the cone and valleys about its base. A large number of altitudes were determined, and the material gotten by my assistant, Mr. F. A. Clark, for a topographical map of the mountain and glaciers, on a scale of two inches to the mile, and with grade curves of two hundred feet vertical intervals. When this map is completed, and the accurate form and dimensions of the glaciers determined, it is my purpose to present a careful account of the past and present conditions of the great volcano.

During the prosecution of this work, Mr. Arnold Hague, assistant in the survey, was engaged upon Mount Hood, carrying out the same system of work, the topography being executed by Mr. A. D. Wilson. The system of volcanic flows, and the existing and extinct glaciers of Hood, were worked out in the same manner as I have done for Shasta, and the results will form a part of our Report.

Later, Mr. S. F. Emmons, accompanied also by Mr. Wilson, with very great difficulty pushed through the forest to Mt. Rainier, and laid the foundation of a similar survey of that cone. His descriptions of the peak and its glaciers will form a most interesting chapter of our work upon the volcanoes.

The following letters addressed to me by Mr. Emmons and Mr. Hague contain an account of their glacier discoveries.

To CLARENCE KING, U. S. Geologist:—

The glaciers of Mt. Tachoma, or Rainier as it is more commonly called, form the principal sources of four important rivers of Washington Territory, viz: the Cowlitz, which flows into the Columbia, and the Nisqually, Puyallup and White rivers which empty into Puget Sound. In accordance with your instructions, Mr. A. D. Wilson and I visited this mountain in the early part of October, 1870, and carried the work of making its complete survey, both geological and topographical, as far as the lateness of the season and the means at our disposal would permit. As the topographical work has not yet been plotted, the figures given in my notes are merely estimates, and liable to subsequent correction. I herewith transmit an abstract from my notes upon the glaciers, embracing those of rather more than half the slopes of the mountain, those on the eastern side, from the extreme southern to the extreme northern point.

The summit of Tachoma is formed by three peaks, a southern, an eastern, and a northwestern: of these the eastern is the highest; those on the south and northwest, being apparently a few hundred feet lower, are distant about a mile and a half to two miles from this, and separated by deep valleys. The eastern peak, which would seem to have formed originally the middle of the mountain mass, is a crater about a quarter of a mile in diameter of very perfect circular form. Its sides are bare for about 60 feet from the rim, below which they are covered by a *névé* having a slope of from 28° to 31°. This *névé* extending from the shoulders of the southwestern peak to those of the northern, a width of several miles, descends to a vertical distance of about 2000 feet below the crater rim, an immense sheet of white granular ice, having the general form of the mountain surface, and broken only by long transverse crevasses, one of those observed being from one to two miles in length: it is then divided up by the several jutting rock-masses or shoulder of the mountain into the Nisqually, Cowlitz and White River glaciers, falling in distinct ice cascades for about 3000 feet at very steep angles, which sometimes approach the perpendicular. From the foot of these cascades flow the glaciers proper, at a more gentle angle, growing narrower and sinking deeper into the mountain as they descend. From the intervening spurs, which slope even more gradually, they receive many tributary glaciers, while some of these secondary glaciers form independent streams, which only join the main river many miles below the end of the glaciers.

The Nisqually, the narrowest of the three main glaciers above mentioned, has the most sinuous course, varying in direction from southwest to south, while its lower extremity is somewhat west of south of the main peak: it receives most of its tributaries from the spur to the east, and has a comparatively regular slope in its whole length below the cascades. There are some indications of dirt-bands on its surface, when seen from a considerable elevation. Toward its lower end it is very much broken up by transverse and longitudinal crevasses: this is due to the fact, that it has here cut through the more yielding strata of volcanic rock, and come upon an underlying and unconformable mass of syenite. The ice front at its base is about 500 feet in height, and the walls of lava which bound its sides, rise from 1000 to 1500 feet above the surface of the ice, generally in sheer precipices.

The bed of the Cowlitz glacier is generally parallel to that of the Nisqually, though its curves are less marked: the ice cascades in which each originates, fall on either side of a black cliff of bedded lava and breccia scarcely a thousand feet in horizontal thickness, while the mouths of the glaciers, if I may be allowed the expression, are about three miles apart. From the jutting edge of this cliff hang enormous icicles from 75 to 100 feet in length. The slope of this glacier is less regular, being broken by subordinate ice cascades. Like the Nisqually its lower extremity stretches out as it were into the forest, the slopes on either side, where not too steep, being covered with the mountain fir (*Picea nobilis*) for several hundred feet above the level of the ice, while the *Pinus flexilis* grows at least 2000 feet higher than the mouth of the glacier.

The general course of this glacier is south, but at its extremity it bends to the eastward, apparently deflected from its course by a cliff of older felsitic rock, more resisting than the lava. The consequence of this deflection is a predominance of longitudinal over transverse crevasses at this point, and an unusually large moraine at its western side, which rises several hundred feet above the surface of the glaciers, and partakes of the character of both lateral and terminal moraines: the main medial moraine of the glacier joins this near its lower end. This medial moraine proceeds from the cliff which bounds the ice cascade source of the glacier on the north, and brings down a dark porous lava which is only found high up on the mountain near the crater. The position of the medial moraine on the glacier would indicate that at least half its mass came from the spur on the east, which is probably the case.

This spur, comprehending the whole mass between the Cowlitz and White River glaciers, has the shape of a triangle whose apex is formed by a huge pinnacle of rock, which as its bedding indicates, once formed part of the crust of the mountain, but now stands isolated, a jagged peak rising about 3000 feet above the glaciers at its foot, so steep that neither ice nor snow rest upon it. One of the tributaries to the Cowlitz glacier from this spur brings down with it a second medial moraine, which is traceable to the mouth of the glacier, though in general these tributary glaciers bring no medial moraines.

On the eastern slopes of this spur between the two above named glaciers, spread secondary glaciers, frequently of great width, but owing to the limited height of their initial points, of inconsiderable length. These end generally in perpendicular cliffs overhanging the rocky amphitheaters at the heads of the smaller streams which flow eastward into the Cowlitz. Looking up from the bottom of one of these amphitheaters one sees a semi-circular wall of nearly 2000 feet of sheer rock, surmounted by about 500 feet of ice, from under which small streams of water issue, falling in silvery cascades on to the green bottom below.

A ridge of high jagged peaks connects this spur with the main range of the Cascade Mts. in the east, and forms the water-shed between the White and Cowlitz rivers. From the connecting saddle one can look northward across the brink of six glaciers, which all contribute to the White river; of these the first four come from the triangular spur already mentioned and are of comparatively little extent. The first two are, however, interesting from the vein structure which they exhibit; they both originate in an irregularly oblong basin, having the shape somewhat of an inclined ellipse, turning on its longer diameter, the outlets of the glacier being opposite the foci. Seen from a high point the veins form concentric lines generally parallel to the sides of the basin; the ends of those towards the center gradually bend round, until they join together in the form of a figure 8, and finally just above the outlets form two small ellipses. They thus constantly preserve a direction at right angles to that of the pressure exerted, downward by the movement of the ice mass, and upward by the resistance to this movement of the rock mass between the two outlets.

The main White River glacier, the grandest of the whole, pours straight down from the rim of the crater in a northeasterly direction, and pushes its extremity farther out into the valley than any of the others. Its greatest width on the steep slope of the mountain must be four or five miles, narrowing toward its extremity to about a mile and a half; its length can be scarcely less than ten miles. The great eroding power of glacial ice is strikingly illustrated in this glacier, which seems to have cut down and carried away on the northeastern side of the mountain, fully a third of its mass. The thickness of rock cut away as shown by the walls on either side, and the isolated peak at the head of the triangular spur, in which the bedding of the successive flows of lava, forming the original mountain crust, is very regular and conformable, may be roughly estimated at somewhat over a mile. Of the thickness of the ice of the glacier I have no data for making estimates, though it may probably be reckoned in thousands of feet.

It has two principal medial moraines, which, where crossed by us, formed little mountain ridges having peaks nearly 100 feet high. The sources of these moraines are cliffs on the steeper mountain slope, which seem mere black specks in the great white field above: between these are great cascades, and below immense transverse crevasses, which we had no time or means to visit. The surface water flows in rills and brooks, on the lower portion of the glacier, and *moulins* are of frequent occurrence. We visited one double *moulin* where two brooks poured into two circular wells, each about ten feet in diameter, joined together at the surface but separated below: we could not approach near enough the edge to see the bottom of either, but, as stones thrown in sent back no sound, judged they must be very deep.

This glacier forks near the foot of the steeper mountain slope, and sends off a branch to the northward, which forms a large stream flowing down to join the main stream fifteen or twenty miles below. Looking down on this from a high over-hanging peak, we could see, as it were, under our feet, a little lake of deep blue water, about an eighth of a mile in diameter, standing in the brown gravel-covered ice of the end of the glacier. On the back of the rocky spur, which divides these two glaciers, a secondary glacier has scooped out a basin-shaped bed, and sends down an ice stream, having all the characteristics of a true glacier, but its ice disappears several miles above the mouths of the large glaciers on either side. Were nothing known of the movement of glaciers, an instance like this would seem to afford sufficient evidence that such movement exists, and that gravity is the main motive power. From our northern and southern points we could trace the beds of several large glaciers to the west of us, whose upper and lower portions only were visible, the main body of the ice lying hidden by the high intervening spurs.

Ten large glaciers observed by us, and at least half as many more hidden by the mountain from our view, proceeding thus from an isolated peak, form a most remarkable system, and one worthy of a careful and detailed study.

Respectfully yours, S. F. EMMONS,
Assistant Geologist.

CLARENCE KING, Esq., U. S. Geologist:

Sir—During the past summer, under your instructions, I visited Mount Hood, in the Cascade range of Oregon, accompanied by Mr. A. D. Wilson, Topographer of the survey, for the purpose of examining the geological and lithological character of the extinct volcano, and also for preparing an accurate topographical map of the mountain and its vicinity, as far north as the Columbia river.

The study of the peak, and its long gently-inclined lava ridges, was replete with important facts, and observations bearing upon the nature and laws that governed the volcanic outflows; but among the most interesting discoveries incident to the trip was the finding of existing glaciers upon the southern slope of the mountain.

The summit of Mount Hood exposes upon the east, north, and northwest sides a bold, precipitous, jagged mass of rock, which forms the outer wall of the old crater, encircling it for three-fifths of the circumference. The remaining portion of the wall is wanting, the other two-fifths presenting a comparatively even slope down to the timber-covered ridges below.

The crater is nearly one-half a mile wide from east to west. The wall upon the inner side rises above the snow and ice filling the basin some 450 feet, while upon the outer side it falls off abruptly for 2,000 feet. This rim of the crater is very narrow; in many places the crest is not more than two feet wide.

Three distinct glaciers have their origin in this basin, each the source of a stream of considerable size; the glaciers of the White, the Sandy, and the Little Sandy rivers.

The White river glacier heads on the eastern side of the crater, and extends in a southeasterly direction. It is nearly a quarter of a mile wide at the head, and about two miles long, extending 500 feet below the line of timber-growth upon the sides of the mountain.

Near the top of the crater a broad transverse crevasse cuts entirely across the glacier. Freshly fallen snow overhangs in projecting banks, the perpendicular walls of ice, making it exceedingly dangerous to approach. At one point only, the fissure may be crossed by an ice bridge. Further down the slope of the glacier transverse crevasses are of frequent occurrence, running nearly parallel with each other; most of them are, however, quite narrow. One broad chasm presented clean, sharply cut vertical sides, for nearly 200 feet in depth, of clear deep blue ice. Marginal crevasses, ice caves and caverns occur; many of the latter are very beautiful and afford fine opportunities for the study of the laminated and veined structure of glacial ice.

Very many of the phenomena attendant upon glaciers elsewhere may be observed here. The terminal and lateral moraines are well marked and extensive. Medial moraines, however, do not appear, because the glacier has no tributaries. Glacial grooving, glacial débris and boulders are quite characteristic.

The glacier of Sandy river is separated from that of the White river, by a high bare ridge, standing boldly up above the ice and dividing the crater into two parts. The glacier descends to the southwest. It is fed by the snow and ice of a somewhat larger area of country, and is considerably broader than the glacier of White river. In length they are about equal.

An immense amount of glacial débris must be annually carried down the stream, whose waters are heavily charged with fine light gray trachytic sand, brought down from above by this moving mass of ice. The character of the rock, a brittle, porous trachyte, is such, that under the wearing action of the glacier it would be easily eroded and ground to fine powder. The very extensive accumulations of sand-banks, which are constantly forming at the mouth of the stream, where it empties into the Columbia river, bear ample evidence of the fact.

The Little Sandy river, a tributary of the main stream, with which it unites, a few miles below the base of the mountain, has its source in the third glacier, which is formed on the western flank of the peak, separated from the Sandy by a high wall, a somewhat broken irregular ridge of trachyte, which extends along the southwest slope of the mountain.

The upper portion or the *névé* of the glacier is inclined at quite a high angle, and is considerably fissured by broad deep crevasses. It has cut into the sides of the mountain a deep, narrow gorge with bare precipitous cliffs. The glacier and the valley of the Little Sandy are both quite narrow.

One of the most marked geological and topographical features of Mount Hood and the vicinity is its very extensive system of extinct glaciers, which everywhere gouged out immense trough-shaped valleys, cutting down deeply into the earlier trachytic lava flows of the old volcano. The entire network of valleys were all connected with two main glaciers; that of Hood river on the north, and the Sandy on the south. The ancient White river glacier was undoubtedly very large; but, as far as my observations have yet extended, had no tributaries.

Respectfully yours,
ARNOLD HAGUE, *Assistant Geologist.*

I propose, if my plans receive the sanction of my chief, General Humphreys, to include Mt. Baker, Mt. St. Helens and Mt. Adams and probably San Francisco Mountain, in this series of monographic surveys; if so, at the close of next summer we shall be in possession of a complete series of maps and studies of all the great isolated volcanic cones of the Western United States.

ART. XXV.—*Contributions from the Laboratory of the Lawrence Scientific School. No.* 18.—*On some rocks and other dredgings from the Gulf Stream;* by S. P. SHARPLES, S.B.

SOME time ago Mr. Pourtales gave me for analysis some specimens of bone, rock, and ooze obtained from the bed of the Gulf Stream between Florida and Cuba, while dredging under the direction of the Superintendent of the U. S. Coast Survey.

The bone was a piece of the rib of the Manatee. For comparison with this Mr. Pourtales obtained a piece of the same bone from the skeleton in the Museum of the Boston Natural History Society. He also furnished me with a number of specimens of coral from the adjacent shores.

The phosphoric acid was determined in every case, except that of the fresh bone, by means of ammonic molybdate. In the fresh bone it was determined by Rose's method with mercury. Before treatment with the molybdate the specimen was in every case submitted to the action of the blast lamp for fifteen or twenty minutes in a platinum crucible; by this means every trace of organic matter and carbonic dioxide was expelled.

The first analysis was that of the bone; it was dark colored and almost destitute of organic matter, but still showed distinct traces of fibrous structure. Its density was much greater than fresh bone and it had become very hard. It was from the dredging of May 9, 1868, in 106 fathoms. By the side of it is placed the analysis of the recent bone, which is also calculated as free from organic matter.

	Old Bone.	Recent Bone.	Recent bone free from organic.
Sp. gr.,	2·83	2·07	
$Ca_3P_2O_8$,	62·40	58·16	92·79
$Fe_2(P_2O_8)$,	7·60	----	----
$Ca\ Co_3$,	26·47	4·52	7·21
SiO_2,	·34	----	
H_2O + organic,	2·67	36·69	
	99·47	99·37	100·00

The second specimen examined was a hard dark colored rock from the dredging of May 15, 1868, off Sand Key, Florida, in 100 fathoms. It was nearly free from organic matter.

The third specimen was similar to No. 2, except that it contained more organic matter and was intermixed with broken shells and coral, and appeared to be of a more recent formation. It came from the dredging of May 9th, 1868, 11th dredging in 116 fathoms.

No. 4 was a loose rock made up of fragments of corals and seemingly held together by calcic carbonate; it was nearly white, contained but little organic matter and only a mere trace of iron; it was from the third dredging, May 1, 1868, in 183 fathoms. The mud in external characteristics resembles the Atlantic ooze, but differed from that examined by Messrs. Forbes and Hunter in being almost destitute of silica and ferric oxide. The silica consists almost wholly of sponge spicules.

	.	3.	4.	Ooze.
Sp. Gr.,	2·81	2·79	2·61	
$Ca\,CO_3$,	36·50	47·11	96·96	85·62
$Ca_3P_2O_8$,	35·54	13·15	1·20	.18
SiO_2,	·49	1·92	2·12	1·52
Fe_2O_3,	14·77	20·23	----	·31
$MgCO_3$,	10·56	12·39	----	4·26
H_2O+organic,	1·46	5·89	----	8·15
	100·33	100·67	100·28	100·04

The corals were examined mainly with reference to the amount of phosphoric acid that they contained. Silliman's analyses, made in 1846, were as good, perhaps, as the state of the science allowed at that time. He seems though to have overlooked one fact in his experiments that Berzelius long ago pointed out, that tri-calcic phosphate is soluble to a considerable extent in neutral or alkaline solutions containing organic matter. In order to confirm this fact I took a solution containing about ·01 pr. ct. of glue and added to it some sodic phosphate and then calcic chloride in considerable excess and afterward calcic hydrate to decided alkaline reaction. The filtrate from the precipitate formed was evaporated to dryness and then tested with magnesium wire after Bunsen's method for phosphorus; it gave a strong reaction.

I also took about 100 grams of *Madrepora palmata*, treated it in the same way as Silliman did his specimens, with the exception that it was put into the acid in a single piece, thereby avoiding any contamination from the mortar. The precipitate contained a large amount of organic matter, but on testing it for phosphoric acid, it was found to be almost free from it, while the coral treated in fresh state gave a strong reaction.

	$CaCo_3$	$Ca_3P_2O_8$	H_2O + Organic.
No. 1, *Oculina arbuscula*, N. Car.,	95·37	·84	3·79
" 2, *Manicina areolata*, Florida,	96·54	·50	2·96
" 3, *Millepora alcicornis*, "	97·46	·27	2·54
" 4, *Madrepora palmata*,	97·19	·78	2·81
" 5, *Agaricia agaricites*,	97·73	·53	1·64
" 6, *Siderastræa radians*,	97·30	·28	2·42
" 7, *Madrepora cervicornis*,	98·07	·32	1·93
" 8, Terebratula shells,	98·39	·61	1·00

My experiments failed to show more than the slighest traces of fluorine and I could only find silica in one or two instances and then in mere traces. There were also traces of iron and magnesia.

The above analyses are interesting from several points of view. In the case of the bone we have first a replacement of tri-calcic phosphate by calcic carbonate. The total percentage of lime having diminished, while iron, which was present only in traces in the original bone, exists in considerable quantity.

In regard to the replacement of the phosphate by carbonate one or two explanations may be offered. Calcic phosphate, as shown above, is soluble to a considerable extent in solutions of organic matter. This will account for the removal of part of that salt. Then again during the decomposition of the gelatine of the bone ammonic carbonate would be formed in considerable quantities. The cartilage of bone containing about 18 per cent of nitrogen which would be equivalent to about 123 per cent of ammonic carbonate, alkaline carbonates decompose calcic phosphate more or less completely; they also precipitate calcic sulphate from solution; forming in both cases calcic carbonate. We should therefore have ammonic sulphate and phosphate going into solution while calcic carbonate would be deposited.

We have now remaining only the oxide of iron to be accounted for; the silica being mostly in the insoluble state may be regarded as adventitious. It is a difficult matter in absence of any data concerning the amount of iron in the waters or bottom of the Gulf Stream or Gulf of Mexico to do any thing more than offer a possible explanation of the presence of so large a quantity of this element. Very few of the analyses of sea water give more than a trace of iron. The waters of the open ocean are almost entirely free from it. But those of inclosed seas, such as the Black and Mediterranean, contain a considerable amount. It is also contained in river water, it being absent in but few of the analyses of such water that have been given.

Now we have in the case of the Gulf of Mexico a sea that is for all practical purposes surrounded by land, and we have also large rivers carrying down in all probability great quantities of iron. This coming in contact with decomposing organic matter will be converted at first into carbonate and deposited; it will then be slowly changed into sesquioxide. This is a change that, it is admitted, is slowly going on at the bottom of most ponds.

The analysis No. 2, of rock gives an instance when this change has gone further, and the phosphoric acid has become much reduced in amount, both by the solvent action of the organic matter and ammonic carbonate and the further deposit of iron, increasing the weight and thus diminishing the percentages of the other components.

Rock No. 3 is evidently composed in part of a rock like No. 2, derived from bone and in part of fragments of shells and corals; these fragments, being almost destitute of phosphoric acid, aid in reducing the percentage. The iron seems to be the cementing material to a great extent in this case.

No. 4 is more recent and consists almost entirely of decayed shells and corals. The magnesia in Nos. 2 and 3 is evidently derived from the sea water, it having replaced part of the lime.

These specimens were selected from among a great number as being typical of the different deposits met with in the dredging. These deposits may have a very near relationship to the bone beds of South Carolina. In the first place I think they show that tendency of calcic phosphate is not toward concentration, but in every case we find the more recent the bone or other material, the more abundant the phosphoric acid.

Now in the case of the bone beds we have, leaving out the silica, a substance of almost the same composition as bone with the addition of a considerable amount of iron; or, in other words, a composition nearly approaching that of No. 2, with the exception that there is less carbonate of lime.

The much larger amount of sand is accounted for by the nature of the surrounding coasts; in the case of the Gulf, the shores are mostly of coral, while in South Carolina they are siliceous. We also have the bones of land and fresh water animals mixed in with these deposits in such a good state of preservation that they can be recognized, and occasionally we find the imprint of shells from the beds below which may have been exposed at some points.

There is another characteristic described by C. U. Shepard, Jr.,* which applies equally well to the deposits from the Gulf. He says the surface of the nodules is glazed over and pitted with numerous small holes; this would answer very well for a description of rock No. 2.

Prof. C. U. Shepard's, Sr.† theory of the concentration of calcic phosphate in a mineral by the gradual removal of calcic carbonate by solution in carbonic acid does not seem tenable in view of the fact that calcic phosphate is also soluble in carbonic acid. The large amount of alkaline carbonates that would also be formed during such a process must also decompose to a considerable extent the calcic phosphate.

Cambridge, Dec. 1, 1870.

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* This Journal, II, vol. xlvii.

† This Journal, II, vol. xlvii, p. 338.

ART. XXVI.—*Calorimetric Investigations;* by R. BUNSEN.*

1. *The Ice Calorimeter.*

THE calorimetric methods hitherto in use are attended with the disadvantage that proportionately large quantities of the calorimetric fluid, as well as of the substance under investigation, must be employed, in order that the loss of heat which unavoidably attends the measurements may be so reduced that all corrections therefor may be small in comparison with the amount of heat to be measured. In the determination of specific heat, especially when the more exact of the methods previously in use are employed, satisfactory results can hardly be anticipated when the amount of material used in the experiments is less than from 10 to 40 grams. The preparation of the rarer substances, in a state of absolute purity, in such quantities often presents almost unsurmountable difficulties, and it is perhaps only on this account conceivable that we are not acquainted with the specific heats even of all the elements which have been isolated in a state of purity, although these determinations are of fundamental importance for the establishment of the atomic weights.

The instrument described in the following pages is designed to aid in overcoming this disadvantage. It is based on the principle of measuring the amount of ice melted by the communicated heat by means of the diminution in volume which this ice undergoes on melting.

The instrument, fig. 1, which was made at the glass blower's lamp, consists of an inner glass vessel, *a*, having the form of an ordinary test tube and melted into the cylindrical glass case *b*. From this case *b* issues the glass tube *c*, to whose upper extremity the iron head-piece *d* is cemented. The inner vessel *a* is filled from α to μ, the outer case *b* from β to λ, with previously boiled water; the remainder of the case *b* together with the tube *c*, is filled up to the height γ with previously boiled mercury. In order to arrange the apparatus for use, a cylinder of ice enclosing the entire vessel *a* is produced in the case *b*, the whole apparatus is then surrounded with snow in a large vessel, and the calibrated scale tube *s*, which has been cemented into the cork with fine sealing-wax, is screwed down through the mercury of the head-piece *d* very tight into the opening of the tube *c*, whereby the scale tube fills itself with mercury. In order that the pressing in of the stopper may be unattended with danger for the rather fragile apparatus, the instrument is

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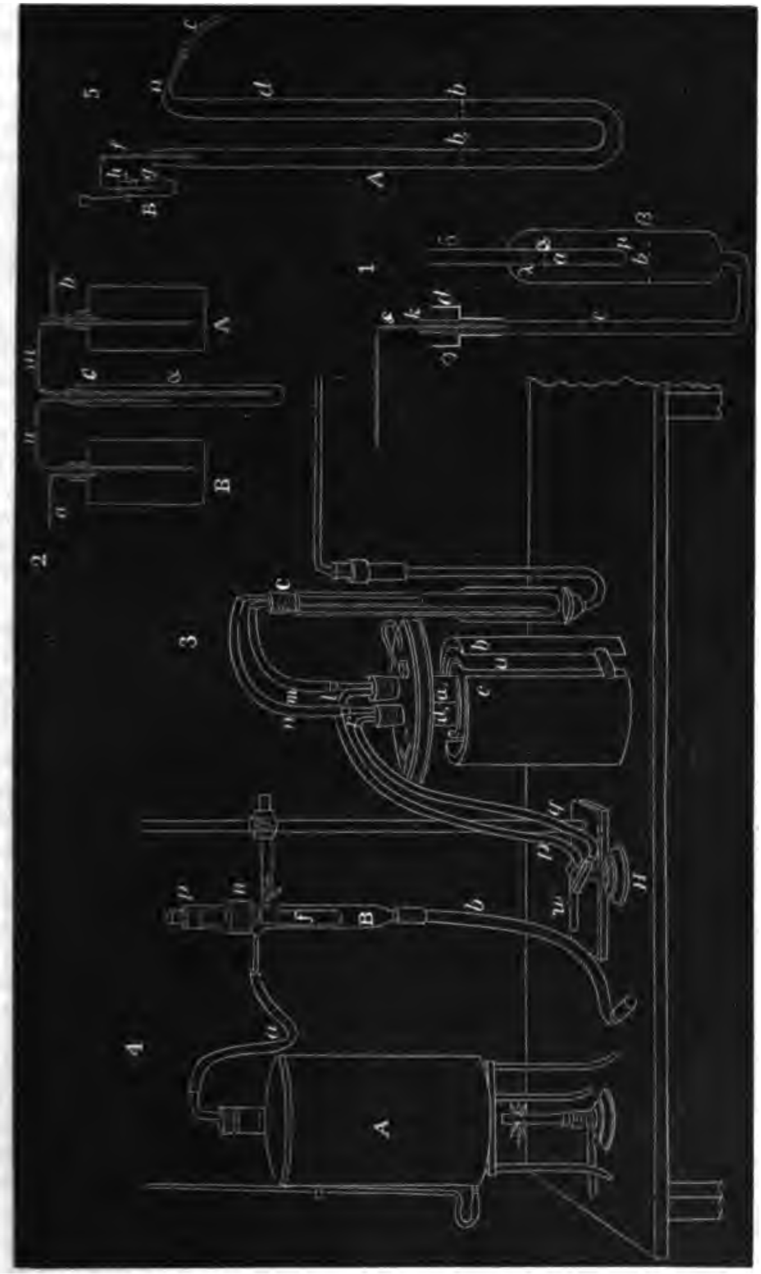
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fastened on a heavy iron stand by means of a vice, whose jaws surround tightly the lower part of the iron head-piece *d*.

The amount of heat which a body evolves in cooling from a given temperature to 0° C., is determined by dropping it into the water in the vessel *a* and thereupon closing the vessel at *b* with a cork, to prevent any circulation of air. If the problem be the relative measurements of quantities of heat, as in the determination of specific heats, then the standard of comparison is directly afforded by the number of scale-divisions which the mercury thread has passed on its retreat. If the readings are rendered in an absolute measure, as for instance, in grams of melted ice, or in units of heat, as the unit in the following pages, (always that quantity of heat being understood which one gram of water at 0° C. absorbs in order to raise its temperature to 1° C.), then it is only necessary to multiply the readings on the scale with a constant which results from the following consideration.

A mercury thread measured in the scale tube, which has the temperature t° and occupies T divisions of the tube after being corrected by the calibration table, weighs g grams. Let further the specific gravity of mercury at 0° C. be S_q, its coefficient of expansion α, then is the volume v of a corrected division on the scale, measured in cubic centimeters,

$$v = \frac{g\,(1+\alpha t)}{S_q\,T}.$$

For the instrument which I used, the values were:

$$g = 0{\cdot}5326 \qquad \alpha = 0{\cdot}0001815 \qquad t = 9^\circ\ \text{C.}$$
$$S_q = 13{\cdot}596 \qquad T = 507{\cdot}4$$

and therefore

$$v = 0{\cdot}00007733\ \text{c.c.} \quad \text{- - - - - - - - - -} \quad (1)$$

If the specific gravity of ice at 0° C. be denoted by S_e, the specific gravity of water at the same temperature by S_w, the weight of melted ice expressed in grams, which corresponds to the volume v, that is, to one scale division with p, then is

$$\frac{1}{\dfrac{1}{S_e} - \dfrac{1}{S_w}} = \frac{p}{v}$$

or

$$\frac{v\,S_w\,S_e}{S_w - S_e} = p \quad \text{- - - - - - - - -} \quad (2)$$

With regard to the specific gravity of ice we have many observations. The following comparison shows how little they agree among themselves. For S_e

Thomson found	0·920	Plücker and Geissler,	0·920
Heinrich,	0·905	Kopp,	0·908
Osan,	0·927	Dufour,	0·922 (max.)
Royer and Dumas,	0·950	Dufour,	0·914 (min.)
Brunner,	0·918		

With so slight an agreement between these different observers, it appeared to me indispensable to determine, with greater exactitude than has hitherto been possible, the value of S_e necessary for the calculation of the constant *p*. I employed for this purpose the following method, in which the sources of error which have made the previous determinations uncertain have been entirely avoided: Fig. 5 is a thick walled U-shaped tube, of difficultly fusible glass, which has been drawn out at *a* to a thick walled point. This is filled with mercury to *b b*, and both limbs are well boiled out, as is done with barometers. The point *a* is provided with a small rubber tube through which, by means of alternate warming and cooling of the air in the limb *a b*, distilled water, free from air, is allowed to enter above the mercury by *b*. If this water be boiled for half an hour and the rubber tube *c* be kept under the surface of water, which has likewise been kept in continual ebullition in a beaker glass, the space *a b* will, as soon as the boiling by *b* is discontinued, fill itself completely with perfectly airless water. The rubber tube *c* is now closed under water by means of a small glass stopper and the point by *a* melted off, which may be easily and safely done with the ordinary non-luminous gas flame, without the aid of the blowpipe, when the part of the tube where it begins to narrow out into the point is so strongly heated that it is filled with steam instead of water. If the apparatus has been weighed before filling with water, and after the filling be weighed again together with the dry point, the weight of the water contained in the instrument will be obtained. The open limb is now completely filled with boiled-out mercury and especially, in order to prevent the adhesion of air bubbles to the glass walls, through a long capillary glass tube. If the apparatus be exposed in the open air to a temperature below 0° C., an ice tube, corresponding to the glass tube, will be formed which at last closes in different places, and still contains water surrounded with ice. By the freezing of these last portions of water the ice already formed is exposed to a very high pressure, which may very considerably alter its specific gravity, may in fact even burst the glass tube eighty-atmosphere strong. In order to remove this disadvantage and permit the ice formation to take place, during its entire duration, under the same pressure, it is simply necessary to sink the whole instrument in sawdust and to expose only the upper part by *a* to air of a temperature below 0° C., after you have previously, in order to prevent the effects of abnormal lowering of the freezing point (Ueber-schruelzung), produced an ice mass by *a*, which is allowed to dwindle by melting to a small granule. The freezing then goes on very regularly from *a* downward to *b* and can be very conveniently regulated by letting the limb containing the water project, according to requirement, more and more above the sawdust. The ice cylinder shows on its basis a very regular hemispherical cavity, which progresses unaltered until its edges touch the mercury by *b*, and the last portions of water have been frozen from above downward. After the formation of ice is at an end, the instrument is still exposed some time to a temperature below 0° C. in order to freeze the last traces of water which exist by *b* between the mercury and the glass walls. The ice cylinder thus formed is perfectly free from air bubbles, and equals in clearness and transparency the finest crystal glass. The piece of apparatus designated in the figure with the letter B is now combined, by means of the cork *e* forcibly pressed in, with the open limb of the apparatus A in such a manner that not a trace of air is included between the cork and mercury, whereby the displaced mercury flows through the capillary tube *f* into the glass vessel, which is filled with mercury to *g*. The capillary tube is cemented with the finest sealing-wax into the smooth and perfectly poreless cork. To cement the cork likewise on the wider tube in which it sits, would be wholly superfluous, as a displacement is as little to be feared as an elastic effect afterward, as I have convinced myself by direct experiment. The instrument thus arranged is placed in a room having the greatest possible constancy of temperature, and is surrounded on all sides with a thick envelope of snow which has, at a temperature above 0° C., become completely coherent without at the same time becoming saturated with water. When, after 6 to 12 hours, the entire instrument has attained 0° C., the mercury vessel is removed from the cork *h*, weighed with the mercury it contains, and, after any mercury which may still adhere to the capillary tube, has been carefully removed, returned to its place. The apparatus is then removed from its envelope of snow, the ice it contains is melted by radiation from a non-luminous gas flame brought in its neighborhood, and it is permitted to attain as before in an envelope of snow, the temperature of 0° C. The mercury vessel is now removed and reweighed. The loss in weight, compared with the first weighing, is the weight of the mercury, whose volume calculated for 0° C. expresses the diminution in volume which the ice cylinder at 0° C. has suffered in melting to water at the same temperature.

Let G_w be the weight of the water frozen,
G_q the weight of mercury which entered the instrument during the melting of the ice,
S_w the specific gravity of water at 0° C.,
S_q the specific gravity of mercury at 0° C.,
S_e the specific gravity of ice at 0° C.,

then is $$\frac{G_q}{S_q} + \frac{G_w}{S^w} = \frac{G_w}{S_e}$$

and therefore: $$\frac{S_w G_w}{G_w + \frac{S_w}{S_q} G_q} = S_e.$$

On account of the great accuracy which the method just described permits, it appeared to me superfluous to make more than three experiments. In the first of these the water froze between −3° C. and −5° C., in the second between −1° C. and −3° C., in the third between 0° C. and −2° C. The following weights, reduced to vacuo, were obtained:

$G_w = 14{\cdot}1580$ grams.
1st expt. $G_q = 17{\cdot}4400$ "
2d " $G_q = 17{\cdot}4624$ "
3d " $G_q = 17{\cdot}4757$ "

If we make further

$$S_w = 0{\cdot}99988 \qquad S_q = 13{\cdot}59600,$$

then the resulting specific gravity of ice S_e will be:

1st experiment,	0·91682
2d "	0·91673
3d "	0·91667
Mean of three expts.,	0·91674

We have therefore for the terms occurring in equation (2),

$$P = \frac{v\, S_e S_w}{S_w - S_e}$$

the values:

$$v = 0{\cdot}00007733 \qquad S_e = 0{\cdot}91674 \qquad S_w = 0{\cdot}99988$$

and thence

$$P = 0{\cdot}00085257.$$

The weight of melted ice e which corresponds to T corrected divisions on the scale is therefore:

$$e = 0{\cdot}00085257\ T \ldots\ldots. (3).$$

Let the latent heat of melting, for water, be l, then will one scale division correspond to $p\, l$ of the previously defined units of heat. For the amount of heat w, expressed in units of heat, which is indicated by T scale divisions, we have therefore,

$$w = p\, l\, T$$

or, if the value 80·025, hereafter to be determined, be substituted for l,

$$w = 0{\cdot}068227\ T \ldots\ldots. (4).$$

As the ice cylinder which surrounds the vessel *a* weighs forty to fifty grams, and it is necessary, on the average, to melt by each experiment only about 0·35 grams of ice, which corresponds to rather more than four hundred scale divisions, it is possible to make with the same ice cylinder as many as 100 different calorimetric determinations and to use the apparatus, arranged once for all, for weeks at a time, when care has been taken that the snow which surrounds the instrument be morning and evening renewed by refilling.

The ice cylinder may be easily produced by a contrivance which is rendered intelligible by fig. 2: A is a sheet tin vessel containing alcohol, B an empty one, both of which are cooled to about −20° C. in a freezing mixture of salt and snow. C represents the inner vessel *a* fig. 1, around which the ice cylinder is to be produced. If suction be applied to the tube *a*, the cooled alcohol of the vessel A will be carried through the vessel C into the vessel B; if suction be then applied in the opposite direction by means of the tube *b*, the alcohol will return through the vessel C into the vessel A. By alternate suction at *a* and *b*, the vessel C may be kept to the height *α* as long as desired at a temperature of −10° C. to −15° C., by means of continually renewed cooled alcohol, and the required ice envelope will be produced in the water mass surrounding the vessel C which is denoted in fig. 1 by *b*. I have given this ice-producing apparatus the form, fig. 3. The *two* semi-cylindrical tin vessels *a* and *b*, which communicate with one another and with the tube *a* by means of tubes above and below, correspond to the *single* vessel A fig. 2, the precisely similar tin vessels opposite these, the outer one of which is denoted by *c*, correspond to the vessel B in fig. 2. These two vessels, each consisting of two concentric chambers, together with the tube *α*, possess, as may be seen, a very large cooling surface, and are sunk in one and the same freezing mixture. The arrangement of the system of tubes, fig. 3, by means of which the circulation of the cooled alcohol is effected, is rendered easy of comprehension, from the fact that the corresponding rubber tubes are designated by the same letters as in fig. 2. The alternate suction to and fro of the alcohol is regulated by the alternating cock H, which communicates with the water air-pump by means of the rubber tube *w*. When this cock is in the one position the rubber tube *q* communicates with the suction tube *w*, the tube *p* however with the atmosphere; in the other position the order is reversed, the suction tube *w* communicates with the rubber tube *p*, and *q* with the outer air. By means of this contrivance, the production of the ice cylinder becomes a very simple operation. The cooling apparatus with its attached rubber tubes is placed in the freezing mixture, *p* and *q* are connected with the alternating cock H, *w* with the water air-pump, the rubber stopper with its tubes m and n is sunk by C in the inner vessel of the instrument, and finally the tubes m and n are placed on the corresponding glass tubes of the cooling apparatus. If now, after the cock of the water air-pump has been opened, the alternating cock be turned alternately back and forth, the cooled alcohol stream may be allowed to operate as long as you please in producing the ice cylinder. The formation of the latter in the apparatus, which stands quite free in the room, may be beautifully observed with the naked eye or through the telescope, and presents not uninteresting peculiarities. The temperature of the perfectly airless water in the outer vessel b, fig. 1, sinks gradually, without freezing taking place, until far below 0° C., while the vessel covers itself externally with an ice crust from the precipitated moisture of the atmosphere; even strong agitation is insufficient to put a stop to this abnormal fluidity. When the temperature has finally sunk very low, a sudden formation of ice takes place, which propagates itself in a few seconds from λ to μ. The whole vessel is filled down to this limit with milky turbid leaves and needles of ice, the water mass from μ to the mercury surface β is on the contrary unfrozen. Now begins, under continued cooling, the first formation of the ice cylinder, which is allowed to increase until its walls have attained a thickness of about 6 to 10^{mm}. That part of the very regularly formed ice crust which lies below μ appears perfectly amorphous, clear and transparent as the purest crystal glass; the portion above μ reaching to λ appears turbid and of a texture not dissimilar to the confused coarse-fibrous, after the instrument has stood several days ready for use at 0° C. in the snow this coarse-fibrous texture changes entirely. The ice mass between λ and μ consists now of small rounded transparent grains of spherical habitus; if, after long use, the instrument be exposed to the temperature of the room, the individual spheres melt off on their surfaces, detach themselves thereby from the adjacent mass, and rise in the fluid; they then appear at times connected with one another like the cells of yeast.

[To be continued.]

ART. XXVII.—*On the Porcelain rock of China;* by Baron VON RICHTHOFEN.—From a letter to Prof. J. D. WHITNEY, dated Shanghai, Nov. 17, 1869.

I HAVE recently made a very pleasant trip of six weeks, going up the Yang-tse to Kinkiang, then into Poyang lake. I visited some places on its eastern affluents, among them the famous King-te-chin, where the Chinese have made nearly all their porcelain for almost three thousand years. I examined the places from which they take the material, crossed over into

An-hwei and Che-Kiang, and descended the Tsien-tang river to Hang-chan, whence I returned to Shanghai. This is probably one of the prettiest countries in China. The hills are overgrown with that prolific vegetation of Azaleas, Rhododendrons, Weigelia and numberless other kinds of low shrubbery which, on account of their beautiful flowers, justify the appellation of the "Flowery Kingdom," at least for this portion of China.

Its geology is rather monotonous, but by no means devoid of interest. Hardly anything is to be seen of the limestones otherwise so prevalent in China. On the eastern slope, sandstones occupy the field almost exclusively. They are folded up to high mountain ranges. Next to them in bulk are porphyries (both quartzose porphyry and porphyrite). The greater portion of the sandstones was certainly, the rest probably, deposited in and after the period of the eruption of the porphyric rocks. I cannot undertake to make an estimate of their stupendous aggregate thickness. Yet, they are surpassed in this respect by a formation on which they are superposed in the neighborhood of the watershed. It consists of clayslates, with sandstones occasionally imbedded; the whole formation stands on edge and preserves a W.S.W. to E.N.E. strike with remarkable regularity, the strata dipping at angles of 70 to 80 degrees alternately N.N.W and S.S.E. During a journey of about one hundred and thirty miles, going from S.S.W. to N.N.E., or at an angle of about 45 degrees with the strike of the rocks, I traversed no other formation but those same slates, standing on edge. This was on the western slope of the range. I have to record the unexpected fact, that the material from which the procelain of King-te-chin is made is taken from certain strata intercalated between these slates, and occurring at several places, separated from each other laterally, that is, at angles with the strike of the rocks. It is a rock of the hardness of feldspar (inferior kinds are not so hard), and of a green color, which gives it in some measure the appearance of jade, to which the Chinese, too, compare it. This rock is reduced, by stamping, to a white powder, of which the finest portion is ingeniously and repeatedly separated. This is then moulded into small bricks. The Chinese distinguish chiefly two kinds of this material. Either of them is sold in King-te-chin in the shape of bricks, and as either is a white earth, they offer no visible differences. They are made at different places, in the manner described, by pounding hard rock, but the aspect of the rock is nearly alike in both cases. For one of these two kinds of material, the place Kaoling ("high ridge,") was in ancient times in high repute; and, though it has lost its prestige since centuries, the Chinese still designate by the name "Kao-ling," the kind of earth which was formerly derived from there, but is now prepared in other places. The application of the name, by Berzelius, to porcelain *earth* was made on the erroneous supposition, that the white earth which he received from a member of one of the embassies (I think, Lord Amherst) occurred naturally in this state. The second kind of material bears the name Pe-tun-tse ("white clay"). I have quite a cargo of both, and of the rocks from which either is prepared. Their examination in the laboratory may be a subject of some interest.

Near Poyang lake, the edges of these King-te-chin schists are overlain by coal-bearing strata, which are almost undisturbed. The locality (Loping) is the first in China which has become of practical value to foreign enterprise; it supplies the greater portion of the coal used by the American steamers on the Yang-tse. I found not a single fossil plant; but certain layers of limestone which overlie the coal carry an abundance of fossil shells, almost exclusively Brachiopods, in an excellent state of preservation. Though I could collect only on the waste-dumps at the pits, I gathered a large number both of specimens and species. As for beauty, the collection ranks first among all I have made in China. The fauna differs from those which I found formerly associated with the coal-measures in the northern provinces; but as I have no paleontologist to consult with, nor even paleontological books, I do not undertake to say what relation in age it bears to those other coal-fields. *Productus* prevails in number. But the former leading fossil, *P. semireticulatus*, is here represented only by a few and small, though very distinct, specimens. Its place is occupied by other *Producti* with spirous shells, of which there are several species; some of them of the shape of *P. horridus*, but costate. *Spirifers* are very scarce. There is one *Cyrtia*, several *Orthis*, etc. But the most curious fossil is one which can only be a *Siphonotreta*. The natural shell has the shape of a night cap, with an opercule on the top, but no area, and is dotted with what appear to be the basal parts of spines; the folds are irregular. The dorsal shell is smooth. Both shells are of a horney substance. *Crinoids*, *Orthoceras*, small *Porcellias*, corals and sponges make up the list of the prevailing fossils.

I believe that the comparison of the various faunas which I have collected in different coal-fields will afford much of interest. No two of them are alike, yet all bear a certain resemblance in a few leading types. I have not yet found any locality that afforded an opportunity for collecting fossils at different geological levels. But every new observation supports my former conclusion, that in the vast extent of China the depositions of coal-beds continued during an extraordinarily long period, in which it shifted repeatedly to different portions of the country. I have some reason for believing that this period commenced even before the Carboniferous epoch, and, though culminating in this, continued on beyond its end.

ART. XXVIII.—*Notes on Granitic Rocks;* by T. STERRY HUNT, LL.D., F.R.S. SECOND PART.

(Read before the American Association for the Advancement of Science at Troy, August 20, 1870.)

(Continued from page 89.)

CONTENTS OF SECTIONS.—§ 16, Granitic veins of Maine; Brunswick; § 17, Topsham, Paris; § 18, Westbrook, Lewiston; crystalline limestones; § 19, Danville, Ketchum; § 20, Denuded granitic masses; § 21, Banded veins; Biddeford, Sherbrooke; § 22, Veins at various New England localities; § 23, Mineral species of these veins; § 24, Veins in erupted granites; § 25, Geodes in granites; § 26, Veins distinguished from dykes; § 27, Volger and Fournet on the origin of veins; § 28, 29, Certain fissures and geodes distinguished from veins opening to the surface; § 30, 31, Temperatures of crystallization of granitic minerals.

§ 16. IT is in the series of micaceous schists with interstratified gneisses (§ 6) which I have elsewhere provisionally designated the Terranovan series,* that I have seen concretionary granitic veins in the greatest abundance and on the grandest scale. This stratified system, which is well seen in the White Mountains, appears to extend southward to Long Island Sound and northeastward beyond the limits of Maine. It is in this state that I have particularly studied the granitic veinstones of this system, whose history may be illustrated by a few examples from notes taken on the spot. In Brunswick the strata near the town are fine-grained, friable, dark colored, micaceous and hornblendic, passing into mica-schist on the one hand, and into well-marked gneiss on the other, and dipping to the S.E. at angles of from 15° to 40°. Very similar beds are found in the adjoining town of Topsham, and in both places they include numerous endogenous granitic veins. The course of these is generally N.W., or at right angles to the strike, though occasionally for short distances with the strike, and intercalated between the beds; the veins vary in breadth from a few inches to sixty feet, and even more. They generally consist in great part of orthoclase and quartz, with some mica and tourmaline, and offer in the associations and grouping of these minerals many peculiarities, which are met with not only in different veins, but in different parts of the same vein. In some cases, colorless vitreous quartz predominates greatly, and encloses crystals of milk-white orthoclase, often modified, and from one to several inches in diameter. At other times pure vitreous quartz forms one or both walls or the center of the vein, or else is arranged in bands parallel with the sides of the vein, and sometimes a foot or more in thickness, alternating with similar

* This Journal, July, 1870, page 83. The rocks of this White Mountain series are, in the present state of our knowledge, supposed to be newer than the Huronian system noticed in § 5, to which, with Macfarlane and Credner, I refer the crystalline schists with associated serpentines and diorites of the Green Mountains.

bands consisting wholly or in great part of orthoclase, or of an admixture of this mineral with quartz, having the peculiar structure of what is called graphic granite, or else presenting a finely granitoid mixture of the two minerals, with little or no mica, and with small crystals of deep red garnet. Prisms of black tourmaline are also met with in these veins, and more rarely beryl and even chrysoberyl. In the rock-cutting on the Lewiston railroad, just below Topsham bridge over the Androscoggin, there is a fine exhibition of these veins, which present alternate coarser and finer grained layers, traversed by long spear-shaped crystals of dark mica passing from one layer to another.

§ 17. A remarkable example of a vein of considerable dimensions is seen in the feldspar-quarry in Topsham, which occurs in a dark fine-grained friable micaceous schist. At the time of my visit, in 1869, the limits of the vein were not seen, though large quantities of white orthoclase and of vitreous quartz had already been extracted. These were each nearly pure, and in alternate bands, the quartz presenting drusy cavities lined with remarkable tabular crystals. One band was made up in great part of large crystals of mica, and portions of the vein consisted of a granular saccharoidal feldspar. The famous locality of red, green and blue tourmalines, with beryl, lepidolite, amblygonite, cassiterite, etc., at Mount Mica in Paris, is a huge granitic vein, which, with many others, is included in a dark colored very micaceous gneiss.

§ 18. In Westbrook numerous small veins of this kind, holding coarsely lamellar orthoclase with black tourmaline and red garnet, intersect strata of fine-grained whitish granitoid gneiss. In Windham the dark colored staurolite-bearing mica-schist of this series is traversed by a granitic vein holding crystals of beryl. In Lewiston a large vein of coarse graphic granite, holding black tourmaline, and showing fine-grained bands, cuts a great mass of bluish gneissoid limestone, which forms an escarpment near the railroad, about half a mile below the town. This limestone, which dips eastward about 15°, is interlaminated with thin quartzite beds, which are seen on weathered surfaces to be much contorted. The bluish crystalline limestone is mixed with grains of greenish pyroxene, and includes nodular granitic masses of white crystalline orthoclase with quartz, enclosing large plates of graphite, crystals of hornblende, and more rarely of apatite. These associations of minerals are met with in the granitic veins of the Laurentian limestones, to be noticed elsewhere. The limestone of Lewiston, however, appears to be included in the great mica-schist series of the region, where similar beds, though less in extent, are met with in various places, sometimes associated with pyroxene, garnet, idocrase and sphene. A thin band of impure pyroxenic limestone, like that of Lewiston, occurs with the mica-schists on the Maine Central Railroad, near Danville Junction, and beds of a purer crystalline limestone were formerly quarried in the south-east part of Brunswick, where they are interstratified with thin-bedded dark hornblendic and micaceous gneiss, dipping S.E. at a high angle.

§ 19. At Danville Junction strata of hornblendic and micaceous gneiss, passing into mica-schists, dip N.E. at moderate angles, and include huge veins of endogenous granite. Two of these appear in the hill just south of the railroad station, apparently running with the strike of the beds. They are seen to rest upon the mica-schist, and in one of them a mass of this rock, three feet in width, is enclosed like a tongue in the granite, which has a transverse breadth of about seventy-five feet. Notwithstanding the apparent intercalation of these granitic masses the proof of their foreign origin is evident in a transverse fracture and slight vertical dislocation of the mica-schists around the broken edges of which the granite is seen to wrap. The endogenous character of this granite is well shown by its banded structure; belts of white quartz some inches wide alternate with others of coarsely cleavable orthoclase, while other portions hold black tourmalines and garnets of considerable size.

The evidence of disturbance of the strata in connection with these endogenous granites is seen on a large scale at the falls of the Sunday River in Ketchum. These mica-schists and gneisses, similar to those already noticed, enclose great masses of endogenous granite, which are seen to be transverse to the strata. On one side of such a mass more than sixty feet wide, the schistose strata are twisted from their regular N.E. strike to the N.W., and so enclosed in the granite as to appear as if interstratified with it for short distances. The banded structure of the transverse granite veins is here very marked. Some portions present cleavage-planes of orthoclase six inches in diameter; other parts, which are less coarse, abound in mica. Similar banded granite veins abound in the adjoining towns of Newry and North Bethel, and sometimes present layers of quartz six inches or more in thickness, besides large crystals of mica, and more rarely apatite. These veins are often irregular in shape and bulging at intervals, and they sometimes run partially across the beds, which seem to have been distended and disturbed, a fact which was also observed in the thin-bedded schists in contact with some of the veins in Brunswick, and is apparently due to the expansive force of crystallization, as noticed in § 27.

§ 20. The locality already described at Danville offers an instructive example of a phenomenon often met with in the region now under consideration, where granitic masses, resisting the actions which have degraded the soft enclosing schists, stand out in relief on the surface, and seem to constitute the rock of the country. A careful search will however show that they are simply veins or endogenous masses of very limited dimensions, rising from out of the mica-schists, which are often concealed by the soil. This is well seen about the lower falls of the Presumpscott near Portland, where the mica-schists with some fine-grained gneisses, dipping S.E. at angles of from 30° to 40°, enclose large numbers of granitic veins, which, though sometimes but a few inches in breadth, often measure twenty or even fifty feet, and are usually very coarse-grained, with white mica, black tourmaline, and more rarely beryl. They are sometimes transverse to the stratification, but more often parallel, and, rising above the soil, are very conspicuous.

§ 21. We have already noticed the exotic granites of Biddeford, which are intruded among fine-grained bluish or grayish silicious strata. These latter are traversed by numerous veins of endogenous granite, which are very unlike in aspect to the intrusive rock. One of these veins near Saco Pool, has a diameter of about an inch and a half, and presents on either wall a layer of yellowish crystalline feldspar about one-fourth of an inch in thickness, which includes long plates of dark brown mica. These penetrate the central portion of the vein, which is a broadly crystalline bluish orthoclase, enclosing small portions of quartz after the manner of a graphic granite. The yellowish and less coarsely crystalline feldspar with its accompanying mica, had evidently lined the walls of the vein while the center yet remained open, and had moreover entirely filled a small lateral branch. The same conditions are seen in the filling of other veins in this vicinity, which are often much larger, and present upon their walls bands of an inch or two of the yellowish feldspar with mica.

The successive filling of a granitic vein is still more clearly shown in a specimen from Sherbrooke, Nova Scotia, which I owe to the kindness of Prof. H. Y. Hind. The vein, which is seen to be transverse to the adherent fine-grained mica-schist, has a breadth of nearly four inches, about two-thirds of which is symmetrical, and is included between two layers, perpendicular to the walls, consisting of a fine-grained mixture of white feldspar and quartz, each about one-fourth of an inch thick, and marked by subordinate zones, more or less quartzose. Within these two bands is a coarser aggregate, consisting of two feldspars, with some quartz and muscovite, plates of which, and crystals of pink orthoclase penetrate an irregular layer of smoky quartz varying from one-eighth to one-half an inch in diameter. This fills the center of the symmetrical portion of the vein, on one side of which is the mica-schist, while the other is bounded by a band of more than half an inch of fine-grained granite with yellowish-green mica, presenting larger crystals of feldspar near the outer margin, where it is succeeded by a layer of pure smoky vitreous quartz of about the same thickness, whose outer surface, against the wall, shows irregular bosses or nodular masses, the depressions between which are occupied by a finely granular micaceous aggregate unlike any other part of the vein in texture. This description may be read in connection with the remarks in § 27.

Dana has described and figured a similar granitic vein, banded with quartz, observed by him at Valparaiso in Chili, (Manual of Geology, 1862, p. 713),* and has moreover maintained that such granitic veins, like ordinary metalliferous lodes, are clearly concretionary in their origin, and have been filled by slow and successive deposits from aqueous solutions. His testimony to the view which I have advocated in this paper had been overlooked by me, or it would have been noticed in § 12.

§ 22. The numerous granitic veins so well known to mineralogists in the mica-schists and gneisses of New Hampshire, Massachusetts and Connecticut, including among other familiar localities, Grafton, Acworth, Royalston, Norwich, Goshen, Chesterfield, Middletown and Haddam, seem from descriptions and from their mineral constituents to be similar to those of Maine, already mentioned. With the exception of Royalston however these localities are as yet only known to me from specimens and descriptions. It is noteworthy that at this last the finely-crystallized beryls are directly imbedded in vitreous quartz, and the same is the case with the blue and green tourmalines of Goshen. A remarkable example of a vein of this character occurs in Buckfield, Maine, described to me by Prof. Brush, where large isolated crystals of white orthoclase, nearly colorless muscovite and brown tourmaline occur in a vein of vitreous quartz. At Paris and at Hebron, Maine, tourmalines are found penetrating crystals of quartz. The flattened tourmalines and garnets found in muscovite at several localities in New England, are well known to collectors, and a curious example of enclosure has been observed by Prof. Brush at Hebron, where crystals of muscovite are encased in lepidolite.

§ 23. The following list includes the principal mineral species found in these granitic veins in New England: apatite, amblygonite, triphylline, autunite, yttrocerite, orthoclase, albite, oligoclase, spodumene, iolite, muscovite, biotite, lepidolite, cookeite, chlorite, chlorophyllite, garnet, epidote, tourmaline, beryl, zircon, quartz, chrysoberyl, automolite, cassiterite, rutile, brookite, uraninite, columbite, pyrochlore, scheelite and bismutite. As I am not aware that chlorite has hitherto been mentioned as a constituent of these veins, it may be said that it occurs in one at Albany, Maine. To the above should probably be added the rare species nepheline, cancrinite and sodalite, which have long been known in boulders of a granite-like rock in Maine. According to information given me by Prof. Brush, green elæolite with white orthoclase and black biotite occurs in a granitic vein twenty feet in breadth, lately observed in the northwest part of Litchfield, Maine.

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* From his Exploring Expedition, Report on the Geology, 1849, p. 570.

§24. We have seen that these endogenous veins are found alike in the gneisses, mica-schists, limestones and quartzose strata of this region. They are also met with in the eruptive granites, small fissures in which are sometimes filled with coarsely crystalline orthoclase, smoky quartz, various micas and zircon. Examples of this are seen in the granites of Hampstead, New Brunswick and Mt. Uniacke, Nova Scotia. The fine green feldspar of Cape Ann, Mass., and the micas, cryophyllite and lepidomelane with zircon, described by Prof. Cooke, from the same region, occur in veins in the hornblendic granites of that locality. Small veins cutting a somewhat similar rock at Marblehead, contain crystallized green epidote with white quartz and red orthoclase.

§25. The veins which we have described are frequently of very limited extent, and seem to occupy short and irregular fissures, while in other cases the mineral aggregates which characterize them occur in nests or geodes. This is seen near Fall Brook in the Nerepis valley in New Brunswick, where the red micaceous granite is in one part very friable, and presents irregular geode-like cavities, sometimes several inches in diameter, which are partially filled by radiating prisms of black tourmaline, accompanied with quartz and albite crystals, and more rarely small octahedrons of purple fluorine. The enclosing granite is composed of deep red orthoclase, with small portions of a white triclinic feldspar, smoky quartz and black mica. The conditions seen at this place recall the description of the famous locality of feldspars, etc., at Fariolo near Baveno in Northern Italy. The rock, described as a granite, resembles, in a specimen before me, some of the intrusive granites of New Brunswick, and contains a pink and a white feldspar, with a little black mica. It includes veins of graphic granite, and also spheroidal masses, which differ in texture from the mass of the rock and present geodes of considerable size, lined with fine large red and white crystals of orthoclase, accompanied by albite, epidote, quartz, fluorine and a greenish mica (or chlorite) all of which, according to Fournet, are so mingled and interlocked as to show that they are of contemporaneous origin. To these are to be added, as occurring in the geodes, prehnite, calcite, hyalite and specular iron. The orthoclase crystals often have adhering to their opposite faces crystalline plates of albite, which are larger than the planes to which they are attached. The crystals of orthoclase moreover frequently present hollowed-out or hopper-shaped faces, which Fournet happily describes as resulting from the forming of the frame-work or skeleton of the crystals, when the material was not sufficient for their completion. A process analogous to this is often seen in crystallization, whether from fusion, solution or vaporous condensation, giving rise in some cases to external depressions and in others to internal cavities in the resulting crystals. Fournet ascribes the formation of the geodes of the granite of Fariolo to a process of shrinking and a subsequent segregation filling the resulting cavities, in which he is forced to recognize the intervention of water, though by no means admitting the aqueous origin of veins, since he holds even those of quartz to have been formed by igneous injection. (*Géologie Lyonnaise*, *278).

§ 26. When we consider the cause which has produced the fissures in the mica-schists and gneisses of New England, which hold the granitic veins already described, it is to be remarked that their comparative abundance, their shortness and their irregularity distinguish them from the fissures which are filled with eruptive rocks. Examples of the latter may be seen near Danville, Maine, where dykes of fine-grained dolerite are posterior to the endogenous granitic veins here occurring in the mica-schist. These dykes may be supposed to be dependent upon movements in the earth's crust opening deep fissures which connected with some softened rock far below. Through such openings were extravasated the exotic rocks, whether granites or dolerites,—more or less homogeneous mixtures, often widely different in composition from the encasing rocks. The endogenous veins, on the contrary, are distinguished not only by their more or less heterogeneous and often banded structure, but by the fact that their principal constituents are the mineral species most common in the adjacent strata.

§ 27. Volger has attributed the formation of the openings containing concretionary veins to the force of crystallization, which is shown to be very great in the congelation of water and the crystallizing of salts in cavities and fissures. Such a process once commenced in an opening in a rock would, he conceived, be sufficient to make still wider the fissure, which might be fed by fresh solutions passing by capillarity through the pores of the rock. If this process were to become concentrated around several points, the intermediate space might be so opened that free crystallization could go on, resulting in the production of geodes in veins thus formed.

Fournet, on the other hand, suggests that contraction in the cooling of erupted granites gave origin to the fissures and geodes now filled or partially filled with crystalline minerals at Fariolo, and we may readily suppose that a process of contraction attendant upon the crystalline aggregation of the materials of sedimentary strata, would give rise to rifts or fissures therein. The lesions thus produced in the solid rocks become more or less completely repaired, if we may so speak, by an effusion of mineral matter from the walls, and thus are generated geodes, irregular masses and many veins. That the process imagined by Volger may in some cases intervene, and may act subsequently to the one just imagined, is highly probable, though we are disposed to assign it but a secondary place in the production of vein-fissures. It offers however the most plausible explanation of the distortion of the thin-bedded strata already noticed in connection with some of the concretionary granitic veins of Maine, which seem by a process of growth to have bent outward the adjacent beds. The vertical transverse veins are, in many cases at least, unsymmetrical, as if they had grown from one side, while the distortion of the beds, sometimes attended by irregular concretions in the banded veinstone, appears at the opposite wall. The notion that the vein-fissures opened as crystallization advanced has been defended by Grüner.

§ 28. It is not here the place to discuss how far the greater and deeper fissures of the earth are dependent upon the contraction of sediments, as just explained, or upon the wider spread movements of the earth's crust, though even of these it may be said that they are more or less directly the results of a process of contraction. It should however be noted that while some fissures of this kind are filled with dykes of erupted rocks (§ 26), others hold concretionary veins, which are to be distinguished from the class of veins just described, inasmuch as the openings in which they were deposited evidently communicated with the surface of the earth. Examples of these are seen in the lead and zinc-bearing veins with calcite and barytine, which traverse vertically the Carboniferous limestone in England, and enclose in their central portions material of liassic age, abounding in the remains of a marine and a fresh-water fauna, which shows these veins to have been deposited in fissures communicating with the surface-waters of the liassic period. For a description of these veins by Mr. Charles Moore, see the Report of the British Association, for 1869, and this Journal, II, l, 365. Similar evidence is afforded by the existence of rounded pebbles imbedded in veins, as observed in Bohemia, and also in Cornwall, where numerous pebbles both of slate and quartz were found at a depth of six hundred feet in a lode, cemented by tinstone and sulphuret of copper. (Lyell, Student's Elements of Geology, p. 598). Not less instructive in this connection are the observations of Mr. J. A. Phillips, on the silicious veinstones now in process of formation in open fissures in Nevada. (L. E. and D. Phil. Mag. (4), xxxvi, 321, 422, and this Jour., II, xlvii, 138). We cannot doubt that the ancient, like these modern veins, have been channels for the discharge of subterranean mineral waters, and it would seem that while the deposition of the incrusting materials on the walls of the fissure is in part due to cooling, and in part perhaps to the infiltration, in some cases, of precipitants from lateral sources, it is chiefly to be ascribed to the reduction of solvent power consequent upon the diminution of pressure as the waters rise nearer to the surface. This conclusion, deducible from the researches of Sorby on the relation of pressure to solubility, I have pointed out in the Geological Magazine for February, 1868, p. 57. See also this Journal, II, l, 27.

§ 29. There is evidently a distinction to be drawn between veins which have been open channels and the segregated masses and geodes formed in cavities which appear to have been everywhere limited by the enclosing rock. In the former case, a free circulation of the mineral solution would prevail, while in the latter there could be no renewal of it except by percolation or diffusion through the rock. A comparison between the contents of geodes and fissure-veins, whether in granitic rocks or in fossiliferous limestones, will however show that these differences do not sensibly affect the mineral constitution of the deposits.

§ 30. The range of conditions under which the same mineral species may be formed is apparently very great. Sorby, from his investigations of the fluid-cavities of crystals, concludes that the quartz which occurs with cassiterite, mica and feldspar in the granitic veins of Cornwall, must have crystallized at temperatures from 200° to 340° Centigrade, and under great pressure, conditions which we can hardly suppose to have presided over the production of the crystallized quartz found in the unaltered tertiaries of the Paris basin, or the auriferous conglomerates of California. In like manner beryl, though a common mineral of the tin-bearing granite veins, like those studied by Sorby, occurs at the famous emerald mine of Muso in New Grenada, in veins in a black bituminous limestone, holding ammonites, and of Neocomian age, its accompaniments being calcite, quartz and carbonate of lanthanum (parisite). Small crystals of emerald are disseminated through this argillaceous somewhat magnesian limestone, which contains moreover a small amount of glucina in a condition soluble in acids. (Lewy, *Ann. de Ch. et Phys.*, liii, 1–26, and Fournet, *Geol. Lyonnaise*, 455).

§ 31. To these we may add the production of various hydrated crystallized silicates, including apophyllite, harmotome and chabazite, during the historic period in the masonry of the old Roman baths at Plombières and Luxeuil, and by the action of waters at temperatures of from 46° to 70° Centigrade; the presence of apophyllite, natrolite and stilbite in the lacustrine tertiary limestones of Auvergne; apophyllite incrusting fossil wood, and chabazite crystals lining shells in a recent deposit in Iceland. The association of such hydrated silicates with orthoclase, as already noticed (§ 13) and as described by Scheerer, where natrolite and orthoclase envelop each other, showing their contemporaneous formation, with many other facts of a similar kind, lead to the conjecture that orthoclase, like beryl and quartz, and perhaps some other constituents of granitic veins, may have crystallized in many cases at temperatures much lower than those determined by Sorby, and that the conditions of their production include a considerable range of temperature, a conclusion which is, however, probably true to some extent, of zeolites also.

It is proposed to continue the subject of granitic veins, and in a third part of this paper to give some facts in the history of the veinstones of Laurentian rocks.

[To be continued.]

ART. XXIX.—*On the Geology of the Eastern Uintah Mountains;* by Professor O. C. MARSH, of Yale College.

ONE of the Expeditions in the Rocky Mountain region, made by the Yale College Scientific party during the past season, had for its special object the study of the vertebrate remains of the Tertiary deposits known to exist in the Green River Valley, but never carefully examined. During this investigation, while endeavoring to reach the junction of the Green and White Rivers, in Utah, the party passed along the base of the Eastern Uintah Mountains, as well as over portions of the range; and as nearly all of this region was entirely unexplored, it is desirable to note its more important geological features.

The route pursued by our party on this expedition was from Fort Bridger, in Wyoming, southeast by way of Henry's Fork to the Green River; thence down the eastern side of the river to the great bend near the mouth of the Vermilion. Then crossing to the western side, and passing over the eastern spurs and foothills of the Uintah Mountains, we proceeded southward to the mouth of the White River. After continuing up this stream for about twenty miles, we returned directly to the Green River, then proceeded to Fort Uintah, and from there struck northward over the Uintah range to Henry's Fork, and back to Fort Bridger by our former route. As the country traversed is entirely impassable for wagons, and it was only with considerable difficulty that a way for our pack-animals could be found, our geological observations were necessarily confined mainly to the immediate route pursued, and even then, in the limited time at our command, could not be systematically conducted. The region passed over, however, proved to be one of the most interesting fields for geological research yet discovered in this country, and hence the results obtained, although fragmentary, will add something to the previous knowledge of Rocky Mountain structure.

Fort Bridger, in Wyoming, from which the Yale party started on their expedition in September last, is situated at the northern base of the Uintah Mountains, about 7000 feet above the sea. The surrounding plain is part of a great basin of denudation, washed out of light-colored clays and soft sandstones of Tertiary age, the deposits in one of the great fresh-water lakes, that replaced the Cretaceous sea from which the mass of the Rocky Mountains emerged. Remnants of the strata removed may be seen at various points around; some in the shape of flat, isolated buttes, and others forming benches, resting horizontally against the sides of the mountains. These fragments serve to show the great original thickness of this lake deposit, which cannot, apparently, have been less than 1500 feet, and may have been much greater. A few miles to the southeast, these soft strata have still further escaped denudation, and are weathered out into fantastic, conical forms, resembling those of the "Mauvaises Terres" formation of Nebraska and Dakota. These bluffs are known in this region as the "Grizzly Buttes," and through them lay our route to the Green River.

A careful examination of this "Bad Land" district soon indicated that a fossil, vertebrate fauna of peculiar interest was here entombed; one apparently older and quite distinct from that preserved in the great Miocene lake-basin east of the Rocky Mountains, which we had recently explored. In the latter deposit, the remains of ruminating mammals were especially numerous, while the entire absence of fishes, and of reptiles, with the exception of a single species of tortoise, was a well marked feature. Here, however, reptilian life had evidently been abundant, and was represented by all its principal forms. Crocodilians, tortoises, lizards, serpents, and fishes had swarmed in the waters of this tropical lake; while Tapiroid mammals, with many smaller quadrupeds, had lived near its borders. Their remains had long been weathering out of the "Grizzly Buttes," which offered so inviting a field, that we devoted a fortnight to their exploration, and were rewarded by the discovery of a large number of extinct vertebrates new to science, which will be described by the writer at an early day.

Proceeding eastward along Cottonwood Creek, and over the divide to Henry's Fork, we found the same Tertiary deposits on either side, still nearly horizontal, and in places beautifully variegated by layers of light green clays, alternating with others of various shades of brown. In addition to the numerous vertebrate remains, a few fresh-water mollusca were observed, especially on Henry's Fork, the more common being *Planorbis spectabilis* Meek, abundant in some of the harder layers, and *Helix altispira* Meek. Farther down the stream, and about fifteen miles from its mouth, several seams of lignite were noticed on the right bank. In the intervening shale were some thin layers of black hornstone, and others containing great numbers of shells, principally Unios and Melanias. One of the latter was apparently identical with the species described by Professor Hall in Fremont's Report (page 308), as *Cerithium tenerum*, which, however, with its associate fossils, is clearly a fresh-water type. A few feet under the lignite, were layers of shale full of *Cypris*, with here and there cycloidal fish-scales and coprolites.

A few miles below, a red sandstone dipping slightly to the N.W. makes its appearance on the left bank, beneath the light-colored Tertiary deposits, and farther down, curves upward into a sharp ridge, of highly inclined strata, through which the stream has obliquely cut its way. On the southern side, these beds form a wall of sandstone, nearly perpendicular, resembling strongly the famous "*Teufels Mauer*" in the Hartz. This ridge, one of the typical foot-hills of the Uintah range, makes a sigmoid curve along the base of the mountains, from which its strata dip away at various angles. The different colored sandstones which compose it are evidently of Mesozoïc age, and probably Cretaceous, as they have below them, farther down the stream, calcareous beds containing undoubted Jurassic fossils. These are in turn underlaid by sandstones, which are probably Triassic, and these again by well marked Carboniferous strata, near the junction of Henry's Fork with the Green River.

At this point the Green River leaves the great Tertiary basin which it drains for 200 miles or more, and cuts through the eastern Uintah Mountains by a succession of narrow cañons, with walls of older rocks, whose exact age can be determined only by a systematic study. In continuing our course down the east side of the river, we passed over several high ridges, composed mainly of hard reddish sandstones and quartzites, more or less metamorphosed, and apparently without fossils. The general inclination of these beds, which are of great thickness, was to the N.E., or away from the Uintah mountain nucleus, but the dip varied greatly at different points. Ripple-marks and oblique lamination showed them to be shallow water deposits, and a subsequent examination of apparently a portion of the same series, on the western side of the river, rendered it probable that a part of them at least are of Silurian age.

On reaching "Brown's Hole," a narrow valley about thirty miles in length, through which the river flows, a series of more recent beds was met with, that are well developed to the southward, where they have played an important part in shaping the present topography of the country. These strata, which are several hundred feet in thickness, lie nearly horizontal, and are mainly composed of conglomerates, and very soft, white, friable sandstones, which at some localities pass into thinly laminated, calcareous shales. At one point on the right bank of the river, a thin seam of lignite was observed in the white sandstone, and about ten miles below, in a high bluff on the opposite side, some of the calcareous layers had all the physical characters of white chalk, although apparently without the same organic structure. As no fossils were detected in these beds, except some obscure remains of plants, their exact age is a matter of some doubt. That they are Tertiary, however, is rendered probable by the fact that, farther down the river, they are seen to rest unconformably on the upturned edges of Cretaceous rocks.

Finding it impossible to proceed with our pack-animals down the river on the east side, we crossed just above the mouth of the Vermilion, and proceeded in a southwesterly course, by a difficult pass, over the eastern extension of the Uintahs. In ascending the mountains from the river we first found a great development of red and purple grits and sandstones, apparently the same as those seen on the eastern side above, but here dipping about 15° to the S.W. Above these strata, and perhaps ten miles to the south, we passed over a series of bright red, thickly bedded sandstones, having the same general inclination, and at least 1000 feet in thickness. In these beds, also, no fossils were detected during the hasty examination we were obliged to make. Resting conformably on this sandstone, was a bed of gray, siliceous limestone, at least 100 feet in thickness, which formed the summits of several of the smaller elevations between the main Uintah range and the Green River, and by its denudation had strewn the region to the southward with its waterworn fragments. This rock, fortunately, contained a few fossils, the most characteristic of which were specimens of *Productus*, *Spirifer cameratus* Morton, *Athyris subtilita* Hall, *Hemipronites crassus* M. and H., a species of *Zaphrentis*, apparently *Z. Stansburyi* Hall, with fragments of *Fenestella* and *Phillipsia*. These remains clearly indicate the Carboniferous age of the limestone, and, indirectly, throw considerable light on the strata beneath it.

Continuing our journey southward, for fifteen miles or more across an elevated plateau, we came suddenly to the overhanging edge of a great basin, which afforded a most striking illustration of the vast amount of erosion to which this region has been subjected since the mountains attained their present elevation. From the base of the Uintahs, as far south as the eye could reach, the soft beds of the more recent formations had been washed away to a depth of one or two thousand feet, leaving at the bottom of the great depression the bare, upturned edges of the variegated Mesozoic strata on which they had rested. The flanks of the adjacent mountains were gashed by deep cañons leading into the basin, showing the source from which the denuding agent came. Our course lay through this basin, and descending with great difficulty by an obscure Indian trail, we passed on, through dry cañons and over steep intervening ridges to Brush Creek, a small stream which now helps to drain this region into the Green River. The rim of this great basin where we descended was composed of nearly horizontal beds of conglomerate, underlaid by light colored clays and sandstones, resting unconformably on the edges of an extensive series of red and yellow sandstones and shales, which dip to the south away from the mountains, but in places have been much curved and folded. The upper, horizontal beds, apparently Tertiary deposits, were evidently identical with those observed on the Green River at "Brown's Hole;" and that valley, as well as this lower basin, owes its present size, if not its origin, to the readiness with which these strata are eroded.

Near Brush Creek, and about six miles from Green River, a seam of bituminous coal was discovered in the side of a dry gorge, which cuts through a high ridge of sandstones and shales. This seam was about a foot in thickness, and indications of others were seen at various points in the basin. The strata containing the coal where first seen dip about 65° to the north, and form part of a denuded anticlinal. The weathering of the thickly bedded sandstone above the coal had developed huge concretionary masses, some of them fifteen feet in diameter, which projected from the cliff, or had fallen into the ravine below. As the age of the coal deposits of the Rocky Mountain region has of late been much discussed, a careful examination was made of the series of strata containing the present bed, and their Cretaceous age established beyond a doubt. In a stratum of yellow calcareous shale which overlies the coal series conformably, a thin layer was found full of *Ostrea congesta* Conrad, a typical Cretaceous fossil; and just above, a new and very interesting crinoid, allied apparently to the *Marsupites* of the English Chalk. In the shales directly below the coal bed, cycloidal fish scales and coprolites were abundant; and lower down, remains of Turtles of Cretaceous types, and teeth of a Dinosaurian reptile, resembling those of *Megalosaurus*, were also discovered.

After passing out of the deeper portion of this basin on our way southward, and proceeding about ten miles beyond a small stream, which on the Government maps is called Ashley's Fork, we crossed a second great depression leading into the Green River Valley. This had been washed out, to a depth of 300 feet or more, in a series of nearly horizontal strata, composed of red shales, sandstones, and conglomerates. In some of the beds there were layers of ash-colored clays, and in these a few mammalian and tortoise bones were found, which indicated clearly the Tertiary age of the deposit. The same beds were seen the next day, near one of the branches of the North Uintah River, dipping about 5° to the N.W., and having beneath them a series of chocolate and ash-colored clays, which, rising gradually, attain a great development farther to the S.E., and form the remarkable Tertiary bluffs along the the Green and White Rivers, which it was our special object to investigate.

Crossing the Green River a few miles above the mouth of the Uintah, we passed eastward to the White River, over an elevated plateau, which was washed out along its sides into the true "Mauvaises Terres" form of conical buttes, beautifully variegated with alternating chocolate, green, and ash-colored layers. An examination of these deposits soon showed that they contained many vertebrate fossils, which were weathering out of the cliffs on every side. Farther up the White River, these remains were more numerous, and large collections were obtained, including many species of Tertiary mammals, reptiles, and fishes, some of which were undescribed. Tortoises were especially abundant, and at one locality no less than eleven of them were seen from one point of view. These various remains proved to be almost all identical with those we had found north of the Uintah Mountains, near Fort Bridger, and hence indicated plainly the synchronism of the two deposits. The great difference in elevation, however, and the character of the intervening region, render it more than probable that they belong to distinct lake-basins, connected in the same system of drainage. To distinguish this ancient lake-region from the Green River Tertiary-basin north of the mountains, the former may appropriately be called the Uintah basin. The stream which connected the two, however, did not flow through the present Green River Valley; although the tongue of Tertiary strata extending up into "Brown's Hole" would seem to point to that depression for a probable inlet from the north.

After exploring the region near the White River for twenty miles or more, and finding the variegated Tertiary clays replaced by hard sandstones and grits of a lower horizon, we turned back, and proceeded by a nearly N.W. course across the Green River to Fort Uintah. Here we procured an Indian guide, who led us nearly N.E. over the mountains by an extremely difficult route. On this journey we first passed over an extensive series of shales and sandstones of various shades of red,—a color which predominates in nearly all the strata of the Uintah Mountains. These beds are evidently of Mesozoic age, and incline 20° to 45° to the southward. At one or two points, large masses of white compact gypsum were noticed in the sandstones. The oldest rocks observed were hard gray and purple sandstones and quartzites, extending to the bottom of the deepest cañons, and apparently forming the central mass of the Uintah range, in place of the granitic nucleus, which gives to the eastern Rocky Mountains and the Sierra Nevadas their most marked character.

While descending the northern slope of the mountains toward the great Tertiary basin of the Green River, which lay in the distance, 2000 feet below us, we passed over a high ridge, from the summit of which appeared one of the most striking and instructive views of geological structure to be seen in any country. Sweeping in gentle curves around the base of the mountains, from near where we stood, many miles to the northward, was a descending series of concentric, wave-like ridges, formed of the upturned edges of different colored strata, which dipped successively away from the Uintahs; those nearest to us, 40° or more, those at a distance, seemingly but little,—altogether a scene never to be forgotten. Apparently we had before us a geological series from the Palæozoic to the Tertiary, but to study it step by step, as we strongly wished, our limited time forbade, and reluctantly we hurried on our journey. Our Indian guide led us across a very deep mountain gorge, called by the hunters of this region "Sheep Creek Cañon," through which a small stream flows eastward into the Green River. The sides of this gorge, where we crossed it, about ten miles above its mouth, are composed of light colored shales, and yellowish, friable sandstones, highly inclined, and towering into precipitous cliffs, some of them nearly 1000 feet in height.

In ascending the northern bank, through a narrow and almost impassable side ravine, we passed over a bed of light gray limestone, about thirty feet in thickness, which rested conformably on the sandstones below, and was inclined to the N.W. at an angle of 25°. This limestone contained an abundance of fossils of characteristic types, that at once established its Jurassic age. Among the most interesting of these were two species of *Trigonia*, one of *Camptonectes*, a *Volsella*, a small *Ostrea*, a *Neritella*, resembling *N. Nebrascensis* M. and H., an *Acteonina*, and a *Chemnitzia*,—nearly all undescribed,—with specimens of *Pentacrinus asteriscus* M. and H. The right humerus of a small Crocodilian was found in the same stratum. Resting immediately on this fossiliferous limestone, was a series of red and gray shales, with intercalated sandstone layers, perhaps in all 150 feet in thickness. In the red beds, white gypsum was abundant, in the form of fibrous seams, and especially in interstratified layers, several of which were one or two feet, and one nearly six feet, in thickness,—a deposit of much scientific interest, particularly in view of its bearings on the origin of gypsum. Next above this series came a bed of yellow sandstone, about 35 feet thick; then 100 feet or more of red and gray shales; and over all, near the head of the cañon, at least 40 feet of yellow and gray sandstone. In the upper part of these beds, *Belemnites densus* M. and H., and a small species of *Rhynchonella* were abundant. The whole series is undoubtedly Jurassic, and probably the best development of the formation yet found in this country.

From this point, we proceeded directly to Henry's Fork, and thence westward, up the stream. Re-examining on our way the "Mauvaises Terres" deposits, we found additional evidence of their early Tertiary age, the lowest beds of the series being evidently Eocene, and resting on the Cretaceous, unconformably. Continuing our journey along our previous route, we arrived safely, after an absence of six weeks, at Fort Bridger.

To Major R. S. LaMotte, in command of this Post, and his associate officers, including Lieut. W. N. Wann, who had charge of our escort, our best thanks are returned for valuable assistance, and many kind attentions. Our grateful acknowledgments are likewise due to Hon. W. A. Carter, and Dr. J. V. A. Carter, residents at the Fort, for important information in regard to the surrounding country, and generous hospitalities.

Yale College, January 20th, 1871.

ART. XXX.—*On the System of the Batrachia Anura of the British Museum Catalogue;* by E. D. COPE.

UNTIL 1858 the Batrachia Anura was a group of animals to which but little attention had been turned, and for which no detailed system based on any general investigations, had been proposed. It was, therefore, a considerable addition to knowledge when the catalogue of the British Museum appeared in that year, and nearly doubled the number of species already known, and arranged them in a system which went into some detail of structure. This detail was, however, almost entirely with reference to external characters. This fact is sufficient to excite question as to the coincidence of the system adopted, with that of nature, and a full examination into the general anatomy of the order, has answered such question unfavorably to it in a very decided manner.* But as authors who have subsequently written do not seem to be at all aware of the demerits of this system, it is proposed here to point out some of them.

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* See the writer on the classification of *Batrachia Anura*, Nat. History Review, 1865, and Jour. Acad. Nat. Sci. Phila., 1866–67.

In the first place the order Anura is divided into three suborders, the Aglossa without tongue, the Opisthoglossa with tongue free behind, and the Proteroglossa, with the tongue free in front. The first group is natural, having been already established by Wagler and Duméril; while the value of the character used to distinguish between the two last is not more than generic at most. Several genera possess the peculiarity of the "Proteroglossa," which in this system are placed among the Opisthoglossa, while the general affinities of the genus Rhinophrynus, the only one of this supposed suborder, are clearly shown by its structure to be those of the family *Bufonidæ* or the toads, on a very slight examination.

The division of Aglossa is supposed by our author to be represented by two series, *Haplosiphona* and *Diplosiphona*, the first including the previously known representatives of the order, the last, the genus *Myobatrachus* Schlegel. Now this last, as I proved by examination of the type specimen at Leyden in 1863, is a dried example of *Chelydobatrachus Gouldii*; an Australian *Bufonid*, with the tongue shrunken away by drying.*

If we now turn to his primary division *Opisthoglossa*, its principal groups are based on one of the most subordinate characters in the order, viz: the *Oxydactyla* and *Platydactyla*, on the presence and absence of the digital dilatations on the ends of the last phalanges; in other words, tree and terrestrial frogs. As all subsequent writers have repudiated these groups, I will pass them with the remark, that the author's reasons for establishing them,—that the characters are so important in the life history of the species—are abundantly sufficient for suspecting their value.

The further subdivision of these groups is based on a variety of characters, some of importance, having been introduced by Müller and Gray, and others newly introduced of very little value. The manner in which they are used is remarkable, and contrary to what would be expected from an examination of the relations of other animals. That is, the characters are treated as of equal importance in all cases, producing a kind of dichotomous system, each group being equal and similar to others, and presenting none of that successional relation which we know so well characterizes nature's groups. The unfavorable impression is strengthened by a further examination into the structure, and the system is found to be little better than if it had been based, dictionary-fashion, on the first letters of their names.

If we mix thoroughly Günther's groups of tree-frogs and not tree-frogs, as the subdividing characters used by him are the same in each, a criticism of the latter will cover both.

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* This error is perhaps not due to the author of the catalogue, as he has seen no specimens.

The presence and absence of maxilliary teeth is an important character, much more so than the conditions of the digital dilatations,—though the esteem in which I formerly held it has been much diminished by the discovery of the genera *Colostethus* Cope and *Eupemphix* Steindachner. Their presence or absence, together with the perfection or imperfection of the ear, as to tympanum, vestibule and eustachian tubes gives our author occasion for dividing each of his series dichotomously into four groups—or three, in the case of the tree-frogs, since the diagnosis of one of them has no answering group in nature. But the presence or absence of the different parts of the auditory apparatus is a character of far less importance than is here assigned to it. The two nearly allied genera *Scaphiopus* and *Pelobates* are separated into two different primary divisions by it, the last to be associated with the *Bombinator* and the first with *Alytes* and *Helioporus*, two genera quite remote in affinities, as well as from the most widely separated regions of the earth. Thus *Helioporus* is Australian, *Alytes* European, and *Scaphiopus* American, and each has sundry allies in its own country, with which it should be arranged. Other most remotely allied genera are associated because of agreement in the structure of the ear. Thus *Discoglossus* is placed in the group *Ranina*, though it represents the family of all others in the *Batrachia anura*, the most remote from the Ranidæ, and which includes beyond a shadow of doubt the genus *Bombinator* which Günther makes not only the type of a different family, but of a distinct primary series, his *Bombinatorina*. Many other instances of the same want of appreciation of natural affinities might be adduced here, but I pass to the toothless or Bufonoid series. Here we find Phryniscid genera separated from their true allies the Engystomidæ, while the latter are placed with much remoter relatives the Bufonidæ, merely because a lesser grade of imperfection of the auditory organs characterizes them.

To come to the characters used to distinguish the families, the same window-pane arrangement prevails. Those employed are the presence or absence of parotoid glands, of palmation of the toes, and of dilated or non-dilated sacral diapophysis. The latter character, noted by Bibron and Gray, is of family value, and the only one of the above to be so estimated. The palmation of the toes is only a generic feature, hardly that in some cases. As this is now agreed to by all good herpetologists, I give it no further notice. The presence or absence of parotoid glands is quiet as worthless in this connection. Thus *Scytopis venulosus* has or has not an immense "parotoid" covering the head and back indifferently, as both Steindachner and myself have observed independently. *Alytes* and *Bombinator*, two European genera of Discoglossidæ little known to our author, but most closely allied, have, the one a small parotoid, the other little separated collections of crypts over the dorsal region, and are hence placed in different families by Günther. *Schismaderma* of South Africa is a true Bufo without parotoids, and Paludicola another member of the true Bufonidæ differs from Bufo in this respect, as Bombinator does from Alytes. *Calamita*, a genus of Hylidæ from the Australian region embraces two species, *C. cyanea* Daud. and *C. dolichopsis* Cope. The first of these has a large glandular mass on the scapular and even cranial regions (and as such the type of a peculiar family of Günther, his Pelodryadidæ) while the second has no glandular enlargements whatever; yet Günther (Zoological Record, 1868) states that they are mere varieties of one species.

To go over all the families in detail, would be unnecessary, as published works have already corrected them. Suffice it to say, that of the fifteen into which the non-tree-frogs are divided, but eight appear by their names to represent natural families, though in character not one of them has a good foundation. Of the nine into which the tree-frogs are divided, but two coincide in extent with modern families, and none in characters. One of the latter embraces but one genus, and is called the *Hylaplesiidæ*, though as Peters has shown by autopsy, the *Hylaplesia* of Boie is a Bufonid, probably a true Bufo. The number of families and subfamilies which might have been constructed on such bases as the above, on genera discovered since the publication of this catalogue, would be considerable, but naturalists have, with one exception* not availed themselves of the privilege.

If we examine the genera of this system the extent of the work of reformation already marked out, becomes more apparent. Thus in his Ranidæ, of thirteen genera, but five belong with Rana, and one of these, Heteroglossa, would be a Polypedatid according to Günther's system. Another, *Stenorhynchus natalensis* Smith, was subsequently redescribed as the type of a new genus and species (*Phrynobatrachus Natalensis*) by the director, although generically undistinguishable from another genus of the same author, *Dicroglossus*. The *Cystignathidæ* contains nothing but members of that family, or rather relations of *Cystignathus*, but is a mere fragment compared with the cohorts that really belong to it. The greater part of all the remaining families of tooth-bearing series belong to it, whether tree-frogs or not. The genus *Plectromantis* Peters, with small digital enlargements on the fingers only, should be placed here, as it is very near to, if at all distinct from the type genus *Cystignathus*. The great extent of this family is paralleled by other Neotropical forms, as the *Formicariidæ*, the *Tyrannidæ*, *Characinidæ*, *Chromididæ*,, etc.

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* Mivart, Proc. Zool. Soc. London, 1869, 280. The writer in one or two instances did the same.

As to the "Discoglossidæ," fragments of four families are represented by its five genera, one of which immediately follows, viz: the *Asterophrydidæ*. In the "Brachycephalidæ" there are placed three genera, Pseudophryne, a true Bufonid, and scarcely distinguishable from the genus Epidalea Cope, which embraces the old *Bufo calamita* of Europe; second, Brachycephalus, which is near Phryniscus and belongs to the Phryniscidæ; and third, *Hemisus*, which is nearer by much to *Engystoma*, but probably forms the type of a distinct suborder?

It is not necessary to examine the genera further, but I turn to the species, where it is proper to express more favorable views. Thus science owes to Dr. Günther a debt of gratitude for the collections, in his British Museum catalogues, of convenient diagnoses of species, with references to many works and authors not accessible to all. His books thus become manuals, and indispensable as the last compilation of an extensive and scattered literature. But it is not only as a compiler that his works are valuable. His usual conscientiousness in attempting the accurate discrimination of species is most praiseworthy, though we cannot help thinking that his estimate of the value of species is sometimes a little interfered with by national and personal predjudices. English, French, and American authors fare the worst at his hands, and we freely admit that in the latter case his criticisms are often deserved, so far as they relate to some of the naturalists of a generation or two ago. These will, however, compare favorably with those who commenced the work in Europe, as Klein, Merrem, Laurenti, Shaw, etc. His countrymen do not, however, escape, and Wagler comes in for the charge of having described, after the much and unjustly criticised work of Spix, "a badly-figured specimen of *Ceratophrys ornata*"* as a new genus, *Hemiphractus*. Now *Hemiphractus* is one of the most remarkable and distinct genera of *Arciferous Anura* of South America, the type of a peculiar family, and Spix's figure represents the type species very well. Prof. Peters first restored the genus.

A serious drawback to the merits of the species work, not only of this, but of Dr. Günther's ichthyological works, is his tendency to ignore species.† This view approaches those expressed by Prof. Schlegel in the field of ornithology. Thus distinct species are continually united, and even good genera are not unfrequently found involved in the undigested mass. This probably results from the very poor opportunities of studying the Reptilia and Fishes enjoyed by the author, except in an alcoholic condition; for the European, of all the faunæ, is the most poorly provided with these forms of life. The North American, one of the best provided in these respects, is almost unknown to Dr. Günther, for it is unfortunate for American students that his works in respect to our fauna are of less value than in any other department. It must, however, be added, that some of the older American authors in this field have been quite as bad in another direction, and in respect to furnishing *well contrasted* specific diagnoses, exceedingly derelict. This has been especially apparent in those who indulge in the execrable practice of publishing preliminary descriptions to "secure priority." This, unless reduced to a system of analytic keys, is nothing but a hindrance to science, and results in warning all students off the ground but the writer, an object which it is safe to presume, he generally has in view.

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* One of the Cystignathidæ.

† I do not allude to his "doubtful-species" which he puts to one side as too briefly described, often very justly.

The system then, presented by the Catalogue of the Batrachia Salientia (Anura), is a phenomenon in the history of our science, and is to my mind one of the least successful of the attempts of *skin-zoology* to interpret nature. That I intended my remark made on a former occasion,* that it was a "complete and practically useful system," in a euphemistic, if not a pickwickian sense, would, I should think, be sufficiently obvious to any who should compare my system with it. But it is neither euphemistic nor pickwickian for subsequent authors to follow me in abolishing nearly all its leading features and in newly defining all the groups, and then to declare that they adopt Günther's system with a few modifications introduced by me.

In accordance with Günther's system, he was compelled to conclude that the Anura do not display any of the remarkable geographical relations exhibited by other groups of animals, but are rather varied in relation to latitude. This conclusion I have shown to be most erroneous, and that the Anura of all groups, represent the wonderful faunal relations of geographical areas in the strongest light,—in a way not less distinct than any known order of animals or plants.

As opposed to these valuable results, we have the position, that "zoological classification" should "repose on more external and readily ascertainable characters," and that it is "well to turn to such other (characters) as can easily be observed;† all which we suppose will only interfere with the progress of knowledge where sincerely believed and held.

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* On Primary divisions of Batrachia Salientia, Nat. Hist. Rev., 1865.

† Mivart, Proc. Z. S. London, 1869, 281–2. This author makes some curious objections to the definitions of some of the groups for example, that of the Arcifera, the parietal fontanelle, etc. The objection is, that these characters mark immature stages of other groups! a point which I have considered in an essay on the "Origin of Genera" subsequently published. It will suffice to state here, that this relation indicates for a character a certain fixed grade of systematic value. The lowest (specific) and some highest, are those that appear earliest in embryonic life.

ART. XXXI.—*On Foraminifera from the Gulf and River St. Lawrence;* by G. M. DAWSON.

BY way of introduction to these notes, I may state that the reader will find some account of the curious and interesting animals to which the paper relates, with figures of characteristic examples, in vol. iv, new series, of the Canadian Naturalist, p. 413; and that several species found in the Gulf of St. Lawrence have been catalogued by Principal Dawson, in the same Journal, vol. v, page 188 *et seq.* The following tables give, however, the only approach to a complete view of the species and their distribution hitherto attempted.

Many of the deeper samples were small quantities of mud brought up in sounding, by Capt. Orlebar, R.N., of the Coast Survey, and by him kindly presented to Dr. Dawson.

The specimens from Labrador were obtained from material dredged by the officers of the Geological Survey; those from Prince Edward Island were from a specimen secured by C. Robb, Esq.; and those from the Bank of Newfoundland were obtained from the late Sheriff Dickson, of Kingston.

The somewhat extensive series from Gaspé Bay was obtained during a dredging expedition in the summer of 1869. The mud was sampled when brought up by the dredge, and reserved for examination, the depth being ascertained as carefully as possible. Several very rich and interesting samples are also from the dredgings of Mr. J. F. Whiteaves, F.G.S., in Gaspé and its vicinity. Mr. Whiteaves has also gone over this material with care, and has detected some additional species.

The means were unfortunately not at hand for ascertaining the temperature at the bottom. But, though there is reason to believe that the water at Gaspé Bay is somewhat warmer than the Gulf of St. Lawrence in general, the mud as it came over the boat's side felt icy cold to the hand, showing even here what a great effect the iceberg-laden Arctic current has on the bottom temperature. The number of species tabulated must not in every instance be taken as a criterion of the relative richness of the localities, as much often depends on the amount of material at disposal. This is especially the case when comparing dredgings with soundings.

The general aspect of the Gulf of St. Lawrence Foraminifera is northern, and in many places closely resembles the fauna of the Greenland coast and the Hunde Islands, as given in Parker & Jones' Memoir.* The Gulf, at least so far as its Foraminifera are concerned, evidently belongs to the Arctic province, the limits of which skirt the Banks of Newfoundland and pass from thence southward to Cape Breton.

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* Philosophical Transactions, 1865.

The refrigeration of its waters depends on the Arctic current, which, entering the Straits of Belle Isle, floods the whole bottom of the Gulf with water almost at the temperature of the Arctic seas. To these conditions the series of collections from Gaspé offers somewhat an exception, and is of a slightly more southern character, both as regards the species represented and the development which they attain. This difference depends on purely local causes, which, while slightly changing the character, give opportunities for a very abundant development of Foraminifera, more especially of the arenaceous forms. Gaspé Bay in no part exceeds 50 fathoms in depth; is about 20 miles in extreme length, well land-locked, and disturbed by no other current than that caused by the ebb and flow of the tide. The depth is not so great as to allow of the incursion of the cold and deep layer to any great extent, and the proximity of land and the shelter thus afforded tend still further to modify its temperature.

The bottom, in most of the deeper parts, is composed of fine sand and mud, and this it is which favors the very large development of arenaceous forms.

Past the mouth of Gaspé Bay sweeps the very strong tidal current of the St. Lawrence, and immediately we pass the shelter of Ship Head and come within its influence, the changes in the Foraminifera become strikingly apparent. The bottom consisting for the most part of clean gravel or coarse sand, most of the arenaceous forms disappear at once, and instead of the abundance of Nonioninas and Miliolas previously found, a very large proportion consist of *Planorbulina lobatula*, which can hold its own, attached to seaweeds and polyzoans. *Polystomella Arctica* also becomes somewhat prominent, while the Lagenidæ and Entosolenidæ appear in abundance.

What few sandy forms do occur are depauperated and composed of very coarse particles. The Foraminifera as a whole however are very abundant, and in some samples dredged by Mr. Whiteaves almost equal in quantity those in the deeper Atlantic soundings.

In the estuary of the St. Lawrence itself, *Bulimina pyrula* becomes a somewhat common form. Among forms which in the Gulf of St. Lawrence may be mentioned as specially characteristic of deep water, are *Nodosaria* (*Glandulina*) *lævigata*, *Globigerina bulloides*, very small; *Bulimina*, principally *B. squamosa*, also small; *Uvigerina pygmæa*, *Cassidulina*.

From depths greater than 100 fathoms all the Foraminifera are very small and delicate; and Lagenidæ, Buliminidæ, Globigerina bulloides, together with a few depauperated Nonioninæ, constitute the greater part of the fauna. From these depths also come many Diatoms, mostly *Coscinodiscus*, and Sponge spicules. *Polystomella striatopunctata* is almost everywhere prevalent, though it nowhere attains to any very great size, and below about 30 fathoms, becomes small and generally rare, and continues increasing in rarity till it almost disappears at 300 fathoms. In some localities, at about 30 fathoms, *P. Arctica* is abundant, and greatly surpasses in size the ordinary *Polystomellæ* occurring along with it. The remaining *P. striatopunctatæ* also at this depth often show a remarkable proneness to run into modifications resembling one or other of the numerous species and varieties into which the genus is subdivided, but as the transition series are complete, it is very difficult to place the bulk of the specimens satisfactorily under them. It has been thought better in the table to include as many as are easily seen to be modified *striatopunctatæ* under that name. *Nonionina Labradorica*, though not so universally distributed as the above, is a very characteristic species in the Gulf. It seems to be best developed and in largest numbers, at about 30 fathoms. It thins off both in numbers and size as we go into shallower water, and decreases much in size, though not so perceptibly in numbers as the water deepens to 100 fathoms and below. There is a remarkable absence of Miliolas in the estuarine parts of the Gulf, which strongly contrasts with their abundance in Gaspé Bay, and also on the Atlantic coast of Nova Scotia, and south.

One specimen of a curious sandy form of *Cornuspira foliacea* was obtained at a depth of 18 fathoms at Gaspé.

Biloculina ringens scarcely occurs above 30 fathoms.

At Murray Bay, which is only about 60 miles below the point where, at least, the surface of the St. Lawrence becomes permanently fresh, the Foraminifera become very scarce and poor. *Polystomella striatopunctata* is the most common, but it has become very small. *Nonionina Labradorica*, *Lituola Canariensis* and *Trochammina inflata* also occur, but all much reduced in size, and scarce relatively to the amount of material examined. On passing from the Gulf to the east of Newfoundland, or to the south of Cape Breton, a change from the Gulf Fauna is immediately detected. *Polystomella striatopunctata*, there so common, becomes rare. *Nonionina Labradorica* to a great extent ceases to appear, and *Uvigerina pygmæa* and *Cassidulinidæ* become more frequent.

The arenaceous *Hippocrepina*, (fig. 2,)* and *Lituolæ* (figs. 1 and 3) are most plentiful at depths less than 20 fathoms. *Lituola scorpiurus* (fig. 4) goes down to the greatest depths in Gaspé Bay, and is yet abundant at 10 fathoms, while the immense *Rhabdopleura abyssorum* (fig. 6) appears only at about

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* The figures refer to the numbers of the wood-cuts.

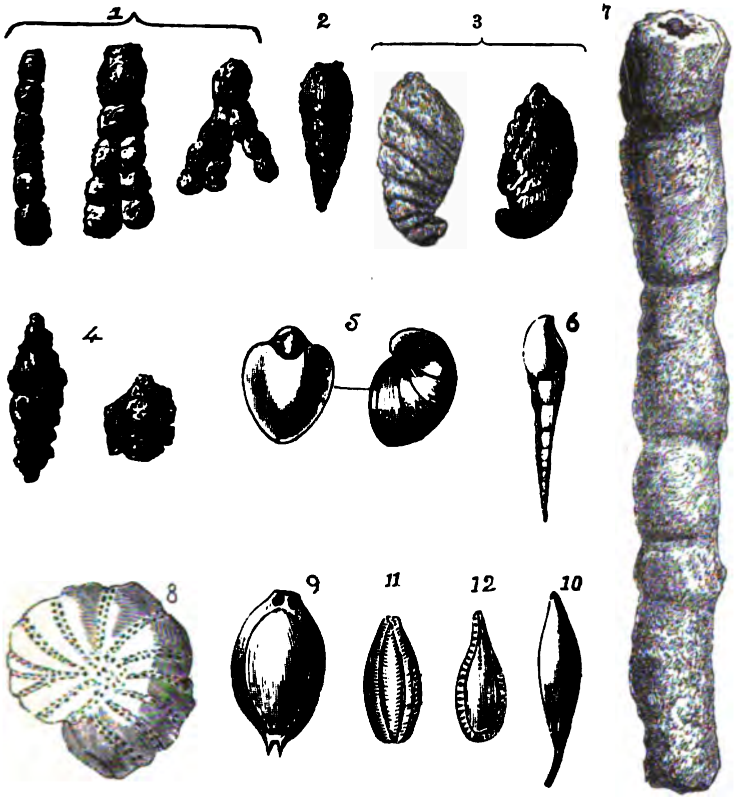


Fig. 1. Lituola findens, P. **Fig. 2**, Hippocrepina indivisa, P. **Fig. 3.** Lituola cassis, P. **Fig. 4.** Lituola scorpiurus. **Fig. 5.** Nonionina scapha, var. Labradorica (313 ftms.) **Fig. 6.** Bulimina Presli, var. squamosa (313 ftms.) **Fig. 7.** Rhabdopleura? **Fig. 8.** Polystomella Arctica. **Fig. 9.** Biloculina ringens. **Fig. 10.** Lagena sulcata, var. **Fig. 11.** Entosolenia striato-punctata. **Fig. 12.** Entosolenia marginata. Figs. 1, 2, 3, 4 and 7 are drawn to a scale half that of the other figures.

TABLE I.—*Supplementary List of Peculiar Arenaceous Forms.*

(See figs. 1 to 4. and fig. 7.)

FORAMINIFERA.	Labrador.	Gaspe Bay, 10 Fathoms, (sand.)	Gaspe Bay 10 to 15 Fathoms.	Gaspe Bay, 16 Fathoms.	Gaspe Bay, 18 to 20 Fathoms.	Gaspe Bay, 16 to 17 Fathoms.	Gaspe Bay, off Grande Greve, 35 Fathoms.	Gaspe Bay, off Grande Greve, 40 to 50 Fathoms.	Gaspe Bay, St. George's Cove.	Riv. St. Lawrence, off Cape Rosier—Whiteaves.
Lituola findens, Parker, fig. 1.	----	----	----	*C L	*	*	----	----	*R	----
Hippocrepina indivisa, P., fig. 2.	----	----	----	*C L	*C	----	----	----	----	----
Lituola cassis, P., fig. 3.	----	*	*C	*C L	----	*	----	----	----	----
Lituola scorpiurus, fig. 4.	*	----	*C	*C L	*	*C	*C L	*C	*C	*C L
Var., fig. 4.	----	----	----	*C L	----	----	*C L	----	----	----
Rhabdopleura, fig. 7.	----	----	----	----	----	*	*C L	*	*C L	*C L

Table II.—*Showing the Distribution of Twenty-three Gatherings of Foraminifera, from the Gulf and River St. Lawrence, and neighboring parts of the Atlantic.*

(C) common. (R) rare. (S) small specimens. (L) large specimens.

FORAMINIFERA.	818 Fathoms, Gulf St. Law., lat. 48° 25′; long. 60° 20′.	250 Fathoms between St. Pierre and Scatari.	200 Fathoms, Cape Camille.	144 Fathoms, Northeast of Anticosti.	140 Fathoms, Gulf of St. Lawrence.	40 Fathoms, Cape St. Nicholas.	Labrador.	Banks of Newfoundland.	Off West Cape, Prince Edward Island.	Off South Coast, Cape Breton, 90 Fathoms.	Gaspe, Northwest Arm, 7 Fathoms.	Gaspe Bay, 10 Fathoms, (sand.)	Gaspe Bay, 10 to 15 Faths.	Gaspe Bay, 16 Fathoms.	Gaspe Bay, 16 to 17 Faths.	Gaspe Bay, 18 to 20 Faths.	Gaspe, bet. Ship Head and Cape Bon Ami, 30 Fathoms.	Gaspe Bay, off Grande Greve, 35 Fathoms.	Gaspe, off Ship Head, 30 to 40 Fathoms.	Gaspe Bay, off Grande Greve, 40 to 50 Fathoms.	Gaspe Bay, Grand Greve, St. George's Cove.	Gaspe, River St. Law., off Cape Rosier Village.	River St. Law., Murray Bay, 15 to 20 Fathoms.
Nodosaria (Glandulina) lævigata	*R			*R	*R												*	*S		*		*R	
Dentalina pauperata	*R																						
" communis							*										*R L			*		*L	
Lagena sulcata														*R		*R	*	*	*R	*L	*R		
" " var. distoma	*	*R		*								*R						*					
" " var. semistriata							*										*	*	*R	*L		*R	
" " var. lævis		*R																					
" " var. substriata										*													
Entosolenia globosa	*						*R								*R			*	*		*R		
" costata							*R		*R			*R		*			*	*R S	*R		*		
" melo, D'Orb.							*R	*R				*L					*R		*R	*R			
" caudata, D'Orb.								*									*S		*R				
" marginata, var. ornata							*R										*S						
" marginata																	*R S						
" squamosa																	*R S		*				
" striato-punctata																	*R						
Polymorphina lactea	*R					*								*	*S		*					*R	
" " var. compressa							*		*RL			*RL	*CL	*L			*L				*R S		
Uvigerina pygmæa								*R		*CS							*R S		*R S		*R		
Globigerina bulloides	*C S	*C S		*			*R	*R									S		*R S				
Texularia agglutinans								*R							*RS								
" " var. biformis							*R																

	Sounding.	Sounding.	Sounding.	Sounding.	Sounding.	Sounding.	Dredging.	Dead Balanus brought up on cod hooks.	Sand from an Anchor.	Sounding.	Sounding.	Dredging.	Dredging.	Dredging.	Dredging.	Dredging.	Dredging.	Dredging.	Dredging.	Dredging.	Dredging.	Dredging.	Dredging.
Textularia agglutinans var. Vernouillina polystropha	----	----	----	----	----	----	*	----	----	----	----	*	----	*	----	*R	----	----	----	----	----	----	----
Bulimina Presli, type	*	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
" " var. pyrula	----	*	*C	*C	*	----	----	----	----	----	*R	----	----	----	----	----	----	----	----	*R L	----	----	----
" " var squamosa	C	*C	----	*	----	----	*R	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
" " var. Bolivina costata	----	*	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
" " var. marginata	----	*	----	*	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
" elegantissima	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	*C	----	----	----	----	----	----	----
Cassidulina lævigata	----	----	----	----	----	----	*R	*	----	----	----	----	*	----	----	*R	*	*	*	*	*	*	----
" crassa	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	*	*	*	*R	*	*	----
Truncatulina lobatula	----	----	----	----	----	----	*CL	*C	----	----	*S	*R	----	----	----	----	*C	----	*C	----	*L	----	----
Rotalia Becarii	*	*R	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Pulvinulina repanda, sub var. Karsteni	----	*R	----	----	----	----	*	----	----	*CS	----	----	----	----	----	----	*	*	*R	*R	*R S	----	----
Patellina corrugata	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	*RS	----	----	----	----
Polystomella crispa var. striatopunctata	*R S	*R	----	*RS	*	----	*	----	*C	----	*CS	*S	*C	*CS	*	*S	*C	*R S	*CS	*R S	*S	----	*C S
Polystomella crispa, var.	----	----	----	----	----	----	----	----	*R	----	----	----	----	----	----	----	----	----	----	----	----	----	----
" arctica,	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	*L	----	*L	----	*L	----	----
Nonionina scapha,	----	----	----	----	----	----	----	*C	----	----	----	----	----	----	----	----	----	*	----	----	*	----	----
" " var. Labradorica	*	*	*	*C	*C	----	*	*R	----	----	*C	----	*	----	*	*	*L	*C	*	*C L	*R	*	*S
Lituola nautiloidea var. Canariense	----	----	*	----	----	----	*	----	----	----	*RS	----	*	*	*C	----	*RS	*C L	----	*C	*C L	*C	*S
Trochamina inflata	----	----	----	----	----	----	----	----	----	----	----	*CS	----	*	----	*CS	----	----	*RS	----	----	----	*S
Cornuspira foliacea ?	----	*R S	----	----	----	----	----	----	----	----	----	----	----	*RS	----	*L	----	----	----	----	*R S	----	----
Quinqueloculina seminulum	*R	----	*R	*	----	----	*	----	*	----	----	*CL	*CL	*CS	----	*RS	*R S	*L	----	*L	*L	*CL	----
" var. subrotunda	----	----	----	----	----	----	*R	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
" var. agglutinans	----	----	----	----	----	----	*	----	----	----	----	----	*S	*	----	*S	----	*	*RS	*R	*R S	*	----
" var. Ferussacii	----	----	----	----	----	----	*R	----	----	----	----	----	----	----	----	----	----	*L	----	*L	----	*L	----
" bicornis var. elegans	----	----	----	----	----	----	----	----	*R	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Triloculina tricarinata	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	*R	*R S	*R S	----	----	----	*R	----
Biloculina ringens	*	----	----	----	----	----	*R	----	----	----	----	----	----	----	----	----	----	----	----	*R	*R	*R	----

20 fathoms, and continues from that point increasing in number and size to the depth of 50 fathoms, which is the greatest depth in Gaspé Bay, where alone it has been found.

The distribution of these Foraminifera would tend, with other facts, to show that these organisms, together with most other marine animals of low organization, do not depend, to any great extent, on the depth or intensity of daylight, but almost entirely on the *temperature* of the water, as Dr. Carpenter maintains in his account of his recent deep-sea dredging, so that they would not give very satisfactory evidence of the conditions of deposits of Post-pliocene or other beds, unless other facts were at disposal to show the depth, when the Foraminifera would give valuable assistance with regard to the climatic conditions at that depth. The quality of bottom has, however, much to do with the general *facies* of the Foraminifera, as with other animals. For, as shown above, calm water, with a bottom composed of fine sand and sediment, is particularly favorable to the arenaceous forms, though, even under these conditions, they do not thrive in the very cold, deep water (such as that below 100 fathoms) in the open Gulf. A strong current at once causes all sandy forms to disappear, mostly, no doubt, from want of the fine materials necessary for their shells, and brings in a large preponderance of *Truncatulinas*, *Lagenidæ*, &c.

The arenaceous forms, with the exception of those which are tubular, constitute a series parallel to the calcareous forms, and the members of which graduate into one another. It seems not improbable that the individuals of the same species may assume either appearance. It does not appear, however, that the same individual can present both forms at successive periods. On the other hand, the sandy forms may really constitute a distinct group parallel to the others. Sketches of some interesting forms are given which do not appear to be precisely similar to described species. These have been kindly examined by Dr. Parker, of London, who regards the Lituolæ represented in figs. 1 and 3 as new species, to which he assigns the names *L. findens* and *L. cassis*. The form represented in fig. 2 he regards as the type of a new genus, to which, from the horseshoe-shaped form of the aperture, he gives the name *Hippocrepina*, naming the species *H. indivisa*.

ART. XXXI.—*Brief Contributions to Zoölogy from the Museum of Yale College.* No. XII.—*Descriptions of new and imperfectly known Ascidians from New England;* by A. E. VERRILL.

[Continued from page 100.]

Family, BOTYLLIDÆ (restricted).

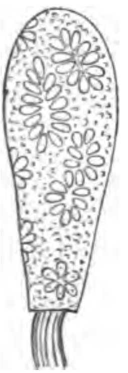
The three divisions established by Milne Edwards among the sedentary compound Ascidians differ so much in internal structure as to entitle them to rank as distinct families: BOTRYLLIDÆ, including *Botryllus* and *Botrylloides;* POLYCLINIDÆ, containing *Polyclinum*, *Amouroucium*, *Aplidium*, and the allied forms; DIDEMNIDÆ, including *Didemnum*, *Leptoclinum*, and several other related genera.

Botryllus Gouldii Verrill. Figures 14 to 19.

Botryllus stellatus Gould, Rep. on Inv. of Mass., 1st ed., p. 320, 1841 (*non* Gætn.).
Botryllus Schlosseri Binney, in 2nd ed. Gould Inv. Mass., p. 3, Pl. xxiii, fig. 319, 1870 (*non* Pallas): Dall, Proc. Bost. Soc. Nat. Hist., xiii, p. 255, 1870.

This species commonly forms thick, fleshy, translucent incrustations on sea-weeds and zoöphytes, the form which it assumes depending upon the shape of the object. The masses are often several inches in length and half an inch or more in width. The animals are short oval, as seen at the surface, and

14.



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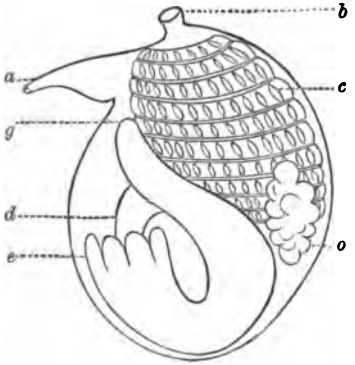

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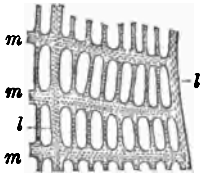

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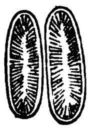


Figure 14.—*Botryllus Gouldii* Verrill, enlarged one half, showing part of a mass attached to the stalk of a *Tubularia*.

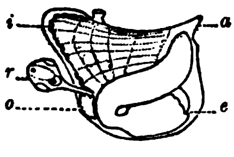
Figure 15.—One of the animals enlarged 20 diameters: *a*, anal orifice; *b*, branchial orifice; *c*, branchial sac; *d*, œsophagus; *e*, stomach; *g*, anus; *o*, right ovary. In this cut the stigmata are too few and too distant and the larger longitudinal vessels were accidentally omitted.

Figure 16.—Portion of the branchial sac of an adult individual, enlarged 40 diameters: *l*, *l*, large longitudinal vessels; *m*, *m*, large transverse vessels, connected by the small longitudinal vessels between the stigmata, and by the large ones.

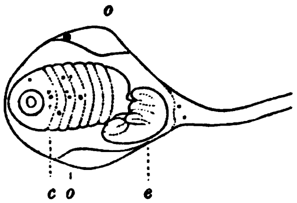
Figure 17.—Two of the stigmata, enlarged 100 diameters, showing the cilia attached to the inner margin.—(All the figures are from camera-lucida drawings by the author, from Brooklyn specimens).

form circular or elliptical groups, of from five to sixteen or more, surrounding circular or elliptical cloacal openings. The "marginal tubes" are numerous in all parts of the common tissue, the enlarged ends appearing as oval or pyriform spots lighter than the ground color. The branchial openings are small and circular, surrounded by a light halo. The animals differ considerably in form, according to the state of contraction. The anal opening is usually considerably more distant from the branchial than in figure 15, and its tube much larger and more divergent. The outer end or branchial side of the body usually projects considerably beyond the branchial opening, as in figure 18. The form of the stomach also differs, and in preserved specimens it is difficult to determine its normal form. Its surface is finely corrugated or irregularly ribbed, with a glandular structure, which is finely granulated.

18.



19.



The colors of the specimens were not very carefully examined during life, but the common tissue is greenish-gray and the animals purplish, with a lighter central spot. When preserved in alcohol the tunic is finely speckled with deep purple, the stomach and ovaries are light yellow. The branchial sac has eight or nine transverse purple vessels, and six or more longitudinal ones that are of the same size and color, with smaller, nearly uncolored ones between (figs. 16, 18). The stigmata are narrow elliptical or oblong (fig. 17). Seen externally the branchial orifice is surrounded by a white spot, and another light spot is situated at the anal opening near the inner end. The marginal tubes are dull yellow, with the enlarged ends often opaque white.

Brooklyn, Long I.,—D. C. Eaton; Charlestown, Mass.,—F. G. Sanborn; Salem,—E. S. Morse.

This species appears to be more nearly allied to *B. polycyclus* of Northern Europe than to *B. Schlosseri*, but is apparently quite different from both.

Figure 18.—Another individual, seen from the left side, and enlarged 10 diameters: *a*, anal tube; *e*, stomach; *i*, ventral duct of the branchial sac; *o*, left ovary; *r*, one of the "marginal tubes" developing as a bud.

Figure 19.—The same bud (*r*, fig. 18) enlarged 40 diameters: *c*, branchial sac with seven transverse vessels, faintly developed; the branchial orifice is not formed, but is indicated by a transparent spot surrounded by a faint circle; *e*, stomach and curved intestine; *o*, *o*, ovaries. Some of the purple pigment cells of the tunic are already developed.

[To be continued.]

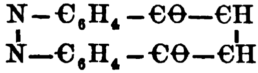
SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the synthesis of indigo blue.*—The beautiful discovery of the artificial production of alizarin is now followed by that of indigo blue. The path to this discovery was opened by Baeyer, who by the action of a new reducing agent succeeded in forming the first derivative of indigo free from oxygen—*indol*, and subsequently in preparing this artificially. The same chemist also reduced isatin to indigo blue, giving thereby further encouragement to the hope of artificially forming indigo blue itself. By the dry distillation of equal molecules of calcic acetate and benzoate, Emmerling and Engler obtained acetophenon, the methyl-ketone of benzoic acid, $\text{Ȼ}_8H_8\Theta$. Nitric acid converts this into two isomeric nitro-derivatives, a crystalline body, $\text{Ȼ}_8H_7(N\Theta_2)\Theta$, which is not susceptible of transformation into indigo blue, and a reddish yellow syrupy compound with the same empirical formula. As the empirical formula shows, two molecules of this body by losing 2 molecules of water and 2 atoms of oxygen would yield one molecule of indigo blue.

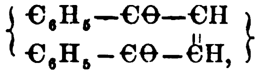
$$2\text{Ȼ}_8H_7N\Theta_3-2H_2\Theta-2\Theta=\text{Ȼ}_{16}H_{10}N_2\Theta_2.$$

By using a mixture of zinc-dust and soda-lime at a high temperature, both these changes occurred, the heat serving to remove the water. Afterward it was found that the water might first be expelled by a carefully regulated heat. When small quantities of the mixture are heated over a good Bunsen's lamp, in narrow test tubes, a dark sublimate is formed on the colder parts of the tube, which on heating gives the characteristic violet vapors of indigo blue. The sublimate also gave with lime and ferrous sulphate a solution of indigo-white, which again by oxidation gave the characteristic purple film. The artificial production of indigo-blue, although in extremely small quantity, is thus rendered certain. The authors give for the structural formula of indigo-blue the following scheme:



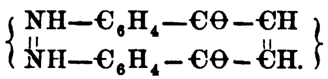
$$\begin{array}{l} N-\text{Ȼ}_6H_4-\text{Ȼ}\Theta-\text{Ȼ}H \\ | \qquad\qquad\qquad\qquad | \\ N-\text{Ȼ}_6H_4-\text{Ȼ}\Theta-\text{Ȼ}H \end{array}$$

so that it represents the azo-derivative of a peculiar ketone, having the formula:



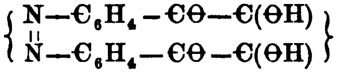
$$\left\{\begin{array}{l} \text{Ȼ}_6H_5-\text{Ȼ}\Theta-\text{Ȼ}H \\ \qquad\qquad\qquad\quad \| \\ \text{Ȼ}_6H_5-\text{Ȼ}\Theta-\text{Ȼ}H, \end{array}\right\}$$

but not yet prepared. In view of the facility with which azo-compounds are converted into hydrazo-compounds, indigo-white will have the formula:



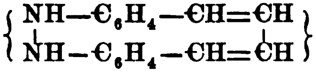
$$\left\{\begin{array}{l} NH-\text{Ȼ}_6H_4-\text{Ȼ}\Theta-\text{Ȼ}H \\ \| \qquad\qquad\qquad\qquad\quad \| \\ NH-\text{Ȼ}_6H_4-\text{Ȼ}\Theta-\text{Ȼ}H. \end{array}\right\}$$

The constitutions of the other bodies belonging to the indigo series will be:



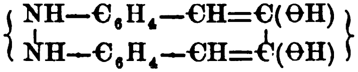
$$\left\{\begin{array}{l}\text{N—Ȼ}_6\text{H}_4\text{—ȻΘ—Ȼ(ΘH)}\\ \text{N—Ȼ}_6\text{H}_4\text{—ȻΘ—Ȼ(ΘH)}\end{array}\right\}$$

Isatin.



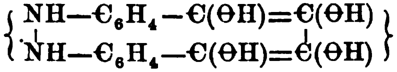
$$\left\{\begin{array}{l}\text{NH—Ȼ}_6\text{H}_4\text{—ȻH=ȻH}\\ \text{NH—Ȼ}_6\text{H}_4\text{—ȻH=ȻH}\end{array}\right\}$$

Indol.



$$\left\{\begin{array}{l}\text{NH—Ȼ}_6\text{H}_4\text{—ȻH=Ȼ(ΘH)}\\ \text{NH—Ȼ}_6\text{H}_4\text{—ȻH=Ȼ(ΘH)}\end{array}\right\}$$

Oxindol.



$$\left\{\begin{array}{l}\text{NH—Ȼ}_6\text{H}_4\text{—Ȼ(ΘH)=Ȼ(ΘH)}\\ \text{NH—Ȼ}_6\text{H}_4\text{—Ȼ(ΘH)=Ȼ(ΘH)}\end{array}\right\}$$

Dioxindol.

The method given above for the artificial formation of indigo-blue does not of course hold out any prospects of success in replacing the natural by the artificial product, but is certainly to be regarded as one of the highest triumphs of synthetic chemistry.—*Berichte der Deutschen Chem. Gesellschaft*, 3ter *Jahrgang*, p. 885, (Nov. 28th, 1870). W. G.

2. *On the products of the distillation of coal tar having high boiling points.*—Among the products of the distillation of coal tar having higher boiling points than anthracene, Gräbe and Liebermann found chrysen $\text{Ȼ}_{18}\text{H}_{12}$. Gräbe has continued the investigation, and has discovered a new hydrocarbon, having the formula $\text{Ȼ}_{16}\text{H}_{10}$, to which he has given the name of Pyren. This hydrocarbon may be isolated by combining it with picric acid, with which it forms a red crystalline mass, having the formula $\text{Ȼ}_{16}\text{H}_{10}+\text{Ȼ}_6\text{H}_2(\text{NΘ}_2)_3\text{ΘH}$. Ammonia unites with the acid and sets free the pyren in the form of colorless leaves which closely resemble anthracen, are soluble in alcohol, benzol, ether and bisulphide of carbon. It melts at 142° C. and distills at a higher temperature than anthracen. Nitric acid readily converts pyrene into nitro compounds. A mixture of potassic chromate and sulphuric acid converts it into pyrene-chinon. Bromine gives two derivatives, $\text{Ȼ}_{16}\text{H}_8\text{Br}_2.\text{Br}_2$ and $\text{Ȼ}_{16}\text{H}_7\text{Br}_3$. Pyrene-chinon is a red powder which is reduced by zinc powder to pyrene, which Gräbe regards as phenylene-napthalin, and for which he gives a complex structural formula.—*Berichte der Deutschen Chem. Gesellschaft*, 3ter *Jahrgang*, p. 742. W. G.

3. *On a new reaction for Chloroform.*—A. W. Hofmann has given a very elegant process by which one part of chloroform in 5000–6000 parts of alcohol may be detected with certainty. The liquid to be tested is poured into a mixture of aniline with an alcoholic solution of caustic soda. When chloroform is present, on gentle heating a violent reaction takes place, with evolution of the characteristic powerful odor of the isonitril. Bromoform and iodoform give the same reaction as well as chloral, but no other known substances.—*Berichte der Deutschen Chem. Gesellschaft*, 3ter *Jahrgang*, p. 769. W. G.

4. *On the homologues of Naphthalin.*—Fittig and Remsen have succeeded in replacing an atom of hydrogen in naphthalin by an atom of methyl or ethyl, by a process similar to that by which ethyl benzol was formed, that is to say, by the action of

sodium upon a mixture of mono-bromnaphthalin with iodid of methyl or ethyl. Methyl-naphthalin is a colorless, limpid, somewhat thick liquid, with a faint aromatic odor. It is insoluble in water, and boils at 231°–232° C. With fuming sulphuric acid it gives methyl-naphthalin-sulphuric acid, $\text{Ȼ}_{10}H_6\left\{\begin{matrix}\text{Ȼ}H_3\\ S\Theta_2.\Theta H\end{matrix}\right.$ Ethyl naphthalin is also a colorless, limpid liquid. It boils at 251°–252° C., and forms an ethyl-naphthalin-sulphuric acid, which gives a well defined copper salt.—*Ann. der Chemie und Pharmacie*, clv, 112. W. G.

3. *On the Spectrum of the Aurora Borealis;* by JOHN BROWNING, Esq., (Monthly Notices of the Royal Astronomical Society, November 11, 1870).—During the display of the Aurora Borealis which occurred on the evenings of the 24th and 25th of October, I confined my attention to observing the spectra of the light, taking it in different parts of the sky. When the spectroscope was directed to the more luminous portions, which were generally of a silvery white, the spectrum appeared to me to consist of only one line. I could not succeed in verifying the position of this line; but it appeared to be situated between D and E in the spectrum. When observing the light of the red portions of the sky, a faint red line became visible. I had no means of verifying the position of these lines with any degree of exactitude; but I was able to throw into the field of view a faint continuous spectrum from a distant light, and also the bright yellow sodium-line produced by a spirit-lamp.

The color of the green line was very peculiar; had I not been able to observe it by comparison, I could not have formed any idea of its position. It was an exceedingly light silvery green, or greenish grey, and often seemed to flicker. Besides the two lines particularly described, I occasionally suspected others, one in the red and one in the blue; but I could not be at all sure of this. The color of the light of the aurora seen over the greater portion of the heavens resembled exactly that of the discharge of electricity from an induction-coil through a vacuum formed from atmospheric air.

II. GEOLOGY AND NATURAL HISTORY.

1. *Geological Survey of Ohio.*—The publication of the Report on the progress of the Geological Survey of Ohio for 1869, is announced on page 146. It consists of: I, a Report of Progress by J. S. Newberry, Chief Geologist; II, Report of Progress in the Second District, by E. B. Andrews, Assistant Geologist; and III, Report on the Geology of Montgomery Co., by Edward Orton, Assistant Geologist. A colored geological map, about a foot square, accompanies the volume, and shows many rectifications of former ideas with regard to the rocks. The region of the Cincinnati uplift, which extends east of north from Cincinnati to the eastern end of Lake Erie, and is occupied about Cincinnati by the lowest exposed rocks of the state, the Cincinnati or Hud-

son River beds, is covered to the north, not solely by the Niagara limestone, as has been supposed, but to a large extent by the Lower Helderberg, and mainly the water-lime beds; and passing eastward from this area, the surface rocks are in succession, the Oriskany sandstone, Corniferous limestone, Hamilton group, the Huron Shale or Genesee and Portage, the Waverly group now proved to be Subcarboniferous, and the Coal Measures, the last mentioned covering nearly all of the eastern third of the state. There is also, on the Lake shore, the Erie Shale, several hundred feet thick, corresponding to the Chemung, a rock hitherto confounded with the Huron Shale.

The Huron Shale, as first found by Mr. Hertzer, contains *fossil remains of fishes* and wood inside of large concretions; and one of the fishes, called the *Dinichthys Hertzeri* by Newberry, had a head three feet long by two broad, with the jaws over two feet in length and five inches deep; the two jaws met in front to form one great triangular tooth which interlocked with two in the upper jaw seven inches long and more than three wide.

The discovery of the Subcarboniferous limestone in patches in the state is announced by Prof. Andrews, of the Survey, at page 91 of this volume. The report of Prof. Andrews, which everywhere shows careful research, relates to the eastern or Carboniferous portion of the State, and contains special descriptions of the rocks and iron ore beds, with sections, lists of fossils, observations on economical products, etc.

Among the most interesting results obtained are those of the chemist, Prof. Wormley, who has proved that the sulphur in the coal is not all or mainly in the state of sulphid of iron, but in that of an *organic sulphur compound.*

We cite the following from Prof. Andrews' Report, on page 108:

"All the authorities on the subject of coal have hitherto supposed the sulphur to be chemically combined with iron in the form of a bisulphide of iron (FeS^2). Prof. Dana, in his recent work on Mineralogy, expresses a doubt in regard to this in the following paragraph, page 756:

'Sulphur is present in nearly all coals. It is supposed to be usually combined with iron, and when the coal affords a *red ash* on burning, there is reason for believing this true. But Percy mentions a coal from New Zealand which gave a peculiarly white ash, although containing from 2 to 3 p. c. of sulphur, a fact showing that it is present not as a sulphide of iron, but as a constituent of an organic compound. The discovery by Church of a resin containing sulphur (see Tasmanite, p. 746), gives reason for inferring that it may exist in this coal in that state, although its presence as a constituent of other organic compounds is quite possible.'

By an examination of Prof. Wormley's table of analyses of the Lost Run coal, it will be seen that in no case is there iron enough in the coal to take up in combination all the sulphur. In No. 27, the sulphur is 1·01 per cent. Adopting for the combination of the bisulphide of iron the proportion given by chemists, viz: iron

46·7, and sulphur 53·3, in 100 parts, the sulphur in No. 27 would require 0·884 per cent of iron, whereas Prof. Wormley finds only 0·09 per cent. This 0·09 per cent of iron would require only 0·102 per cent of sulphur to make the usual iron pyrites, and there are consequently 0·908 per cent of sulphur elsewhere in the coal than in combination with iron.

Another marked illustration of the disproportion of sulphur to the iron in a bituminous coal is found in the analysis of a coal from Washington county. The coal is a white ash coal, and the sample analyzed had been in the cabinet of Marietta college for fourteen years, and showed none of the usual tendency to disintegrate from a change of the bisulphide to the sulphate of iron, a salt which, in crystallizing, breaks the coal by its expansion. The sample was found by Prof. Wormley to contain only 0·390 per cent of iron, but 3·330 per cent of sulphur. There should have been but 0·455 per cent of sulphur, if the sulphur were limited to a bisulphide of iron."

Prof. Andrews observes, on p. 133, that *gold has been taken from the Drift* at several points in Licking Co., and that in the summer of 1868, gold dust was gathered to the value of seventeen dollars.

Prof. Orton was occupied with Southwestern Ohio, which he is evidently studying with much care. Some observations of his in this region on a peat bed beneath the drift, a discovery of the survey, are published on page 54 of vol. 1, of this Journal for 1870. A large number of analyses of limestones and other rocks of this part of the state by Dr. Wormley are given on pages 151 to 153. They show that the Niagara limestone is a true magnesian limestone, containing 40 to 50 per cent of carbonate of magnesia.

2. *Report on the Geological Survey of Iowa;* by Charles A. White, M. D.: Geological Corps, C. A. White, State Geologist; O. H. St. John, Assistant; Rush Emery, Chemist. Vol. I, 381 pp. large 8vo, with maps, sections and views. Des Moines, 1870.—The geological survey of Iowa was first undertaken by Professors James Hall and J. D. Whitney, who published their valuable Report, a large octavo volume, in 1858. In 1866 the survey was resumed, under the order of the State, by Prof. White, but was unfortunately cut short again by the Legislature before the work was half done, yet not before important results were obtained, as shown in the volume just now issued. It is the first of the two volumes of which the Report is to consist. This first volume is a clear and succinct account of the physical geography and geology of the State, with details respecting several of its counties. After a general view of the Iowa rocks, it treats in its first part, of the surface features, including its elevation, drainage system, lakes, caverns, &c.; the Drift and other Quaternary deposits; the soils, prairies and forest-regions; its climate (a chapter, prepared by Mr. T. S. Parvin). In its second part, it takes up the geology, speaking of the several rocks in order of age, giving their characters, characteristic fossils, distribution, etc. Part third, is occupied by

a chapter on the counties of Southwestern Iowa. We select a few facts from the Report.

The thickness of the Lower Silurian is stated as 1160 feet (of which 550 are Primordial); Upper Silurian, (Niagara group) 530 feet; Devonian (Hamilton group) 200 feet; Subcarboniferous, 530 feet; Coal measures, 600 feet; Cretaceous, 330 feet; following which is the Drift; in all, less than 3200 feet for the maximum thickness.

Azoic rocks occur over a few acres in the extreme northwest corner of the State. The Subcarboniferous rocks, which extend northwestward across the State, consist of four subdivisions, the same that are recognized by Worthen in Illinois; 1, the Kinderhook group, the lowest and widest in extent, reaching farthest north; 2, the Burlington limestone, of much less extent northward; 3, the Keokuk limestone (in which the Warsaw limestone is included), with still less of northward extension; and 4, the St. Louis limestone, reaching north nearly as far as the Kinderhook group. The 5th or Upper division, the Chester limestone, does not reach to within a hundred miles of the southern boundary of Iowa. The Coal measures are divided into the Lower, the Middle, and the Upper; and the Upper *is largely limestone*, a rock much like that of the Subcarboniferous, and formerly supposed to be of that group, but proved by Dr. White on both geographical and paleontological evidence to be Upper Carboniferous. The chapter on the Middle Coal Measures is by the Assistant Geologist in the Survey, Mr. O. H. St. John. Sections are given of the Coal measures, as well as of the other rocks.

The subject is throughout presented in excellent style, simple enough for the popular reader, with much of practical value, and yet exact and concise in its scientific descriptions and statements; and the work in its typography as well as its science is an honor to the State. The volume contains a geological map-model of the State, made up of layers of paper colored and lettered to represent the successive rocks—an admirable contrivance of Dr. White's, for popular illustration, and one that may be of great service in public lectures on the science. It is particularly adapted to regions of nearly horizontal rocks.

The second volume of the Report is to be devoted to detailed geology, lithology, mineralogy, and chemistry, and will be accompanied by a geological chart of the State. The Chemical Report will be by Prof. Emery, who, Dr. White observes, "has performed his duties with a zeal and conscientiousness worthy of all admiration."

3. *Report of the Geological Exploration of the Fortieth Parallel, made under the direction of Maj. Gen. A. A. Humphreys, Chief of Engineers, by Clarence King, U. S. Geologist.* Vol. III, *Mining Industry;* by JAMES D. HAGUE, *with Geological contributions by* CLARENCE KING. 647 pp. 4to, with xxxvii plates on stone, and an Atlas. 1870, Washington, Government Printing Office.—The prompt publication of this volume on the Mining

Industry of Nevada and Colorado, within a year from the close of the field-work of the 40th parallel survey, is a good omen for the early completion of the whole report.

The present book, the third volume, although the first in the order of publication, opens with a general sketch of the western mining districts, and an elaborate monograph on the geology of the Washoe district, and the general structure and mode of occurrence of the Comstock lode by Mr. King, covering 97 pages. Then follows an exhaustive treatise on the exploitation of the Comstock mines, and the mechanical and metallurgical treatment of their ores, by James D. Hague, supplemented by a brief chapter on the Chemistry of the Washoe process by Arnold Hague, the whole occupying 198 pages. This is followed by a chapter of 150 pages on the mines of Central and Eastern Nevada by J. D. Hague, with geological contributions by S. F. Emmons, and A. Hague, containing descriptions of the Reese River, White Pine and Egan Cañon districts. Chapter VII, by Mr. King, is on the Green River Coal Basin, and contains paleontological contributions by F. B. Meek. The remaining three chapters, by J. D. Hague, are devoted to a general sketch of Colorado and a detailed account of gold and silver mining in that territory. The work is supplied with an excellent index, and is accompanied by an atlas of xii plates, admirably engraved and printed by Julius Bien of New York. This volume contains a very large number of newly observed facts, which have been calmly considered; and the conclusions therefrom are clearly and candidly set forth. It is not too much to say that the descriptions of the Washoe region, and the illustrative maps showing the geology and topography of the Comstock lode by Messrs. King and Gardner, with the maps, sections and elevations of the different parts of the mines and workings, surpass in completeness and perfection of execution, any similar work ever published. The chapters by Mr. James D. Hague on the methods of exploitation and treatment of the ores of the different districts give, in a masterly manner, the facts and details on these points, and also contain a large amount of carefully collated statistics, never before published, regarding the cost of production, and the yield of the mines up to 1870. Mr. Hague's practical experience in mining, and his thorough knowledge of the scientific principles involved, together with his candid and discriminating treatment of the facts under consideration, give great weight to his conclusions, and render this volume the most valuable contribution yet made to the literature of the Mining Industry of the United States. This book should be studied by every one interested in the development of our western mining regions, and Congress would do a great service to the country if it should authorize a popular edition to be published for general distribution.

Mr. King announces that his report will be completed in five volumes. Vol. I, Systematic Geology; Vol. II, Descriptive Geology; Vol. III, Mining Industry; Vol. IV, Zoölogy and Paleontology; Vol. V, Botany. The whole report forms No. 18 of the Professional papers of the Engineer Department, U. S. Army.

4. *The Literature of Kent's Cavern, near Torquay, Devonshire.*—Besides the five Reports of the Committee for exploring Kent's Cavern, published by the British Association in the volumes for the years 1865 to 1870 inclusive (the first one of which was republished in vol. xliii of this Journal, 1867), various important publications have been made by Mr. Wm. Pengelly, F.R.S., &c., in the Transactions of the Devonshire Association for the Advancement of Science, etc., which have also been reprinted in pamphlet form. These include the following: *The Literature of Kent's Cavern, prior to* 1859, 54 pp. 8vo, 1868.—*Condition of some of the bones found in Kent's Cavern*, 8 pp. 8vo, 1868.—*The Literature of Kent's Cavern, Part II, including the whole of the Rev. J. MacEnery's Manuscript*, 310 pp. 8vo, 1869.—*On the alleged occurrence of* Hippopotamus major *and* Machairodus latidens *in Kent's Cavern*, 25 pp. 8vo, 1869.—Mr. Pengelly was on the British Association Committee, and served as its Reporter. He has also published, in the same Transactions, *On the Antiquity of Man in the South-west of England*, 34 pp. 8vo, 1867.—*On the Introduction of Cavern Accumulations*, 12 pp. 8vo.—*On the Literature of the Caverns near Yealmpton, South Devon*, 25 pp., 1870; and other papers on the Geology of Devonshire.

5. *Atlas der Krystall-formen des Mineralreiches;* von Dr. ALBRECHT SCHRAUF, ersten Custos des K. K. Hof-Mineralien-Kabinets, Wien, etc. 4to, II Lieferung.—Dr. Schrauf of Vienna is one of the best crystallographers of the age, as well as an excellent physicist. He has commenced in this Atlas a large and beautiful work on the crystalline forms of minerals, having just published the second part out of the twenty of which it is to consist. The order in which the mineral species are taken up is alphabetical. The Second part, just now issued, contains plates 11 to 20, illustrating the species from Anglesite to Apatite inclusive, and each plate is occupied with sixteen figures drawn and engraved with great exactness. Under anglesite there are 75 figures; under anhydrite, 16; under apatite, 36; and so on. The text contains crystallographic descriptions of the several figures, and the fundamental dimensions and angles, but without tables of the inclinations between the various planes. Many of the figures are by Dr. Schrauf himself; and in all cases references are given to the authority. The work would be a very valuable companion to any mineralogical cabinet or library. It is printed in a style worthy of the Vienna press.

6. *Synopsis of the Extinct Batrachia and Reptilia of North America;* by EDWARD D. COPE. Part III. pp. 235, to 252 with two large plates.—This third part continues Prof. Cope's very valuable work on our fossil Batrachians, Reptiles and Birds. It is devoted mainly to the birds, and describes at length the species *Sula loxostyla* Cope, from the Miocene of Calvert Co., Maryland, and *Meleagris superbus* Cope, (on a following page, recognized as having been first announced by O. C. Marsh as *Meleagris altus*), from the Post-pliocene of Monmouth Co., N. J. It contains also

an account of some footprints of Batrachians and Reptiles. Next follows the CONCLUSION, containing a synoptical table showing the stratigraphical positions of all the species noticed in his three parts, and another, their distribution in time; and then, general observations on the relations of the species, and some stratigraphical observations.

7. *The Phosphate Rocks of South Carolina: their History and Development*; by FRANCIS S. HOLMES, A.M., of Charleston, S. C. 88 pp. 8vo. Charleston, 1870.—This Report is evidently intended as a popular exhibition of the resources of South Carolina in phosphatic deposits, and of some of the companies engaged in mining them. The author advocates the untenable opinion that the phosphatic material was originally an Eocene formation, and that what occurs now elsewhere was washed out of the Eocene marl into its present position; the multitudes of sharks teeth in the Eocene indicating in his view that sharks and other fishes were the main source of the phosphoric acid.

8. *Geognostisch-mineralogische Fragmenta aus Italien.* III Theil: *Die Insel Elba*; von Prof. G. VOM RATH, in Bonn. pp. 591–732, from the Zeitschr. d. deutschen geol. Ges., 1870, with two plates.—Like all of Prof. von Rath's papers this is a very thorough treatise, both geologically and mineralogically. The plates contain figures of rare forms of the species Quartz, Orthoclase, Beryl, Tourmaline, Petalite (Castor), Sphene, and Ilvaite; besides a map of the Island of Elba.

9. *Lophiotherium sylvaticum.*—Dr. Leidy has so named a species of fossil mammal, based on a portion of the lower jaw found by Prof. Hayden on Henry's Fork of Green river, Wyoming.—*Acad. N. Sci. Philad.*, Nov. 15, 1871.

10. *Auchenia Californica.*—Several bones obtained by Prof. J. D. Whitney, and labeled "under Table mountain near Shaw Flat, Tuolumne Co., California," have been referred by Dr. Leidy to a new and large extinct species of Lama and named as above.—*Id.*

11. *Protohippus of Leidy.*—Dr. Leidy observes that the genus *Hippidion* of Owen, instituted in his paper on the Fossil Equines from Central South America (Phil. Trans. 1869), is essentially that established by him in 1858 under the name *Protohippus.*—*Id.*

12. *Fossil Reptiles of the Cretaceous of Kansas.*—Prof. Cope has recognized among specimens received recently from Kansas, *Elasmosaurus platyurus* Cope, *Polycotylus latipinnis* Cope, *Liodon proriger* Cope, and three new Liodons, which he names *L. ictericus*, *L. Mudgei*, and *L. dyspelor*. The last was allied to *Mosasaurus Brumbzi*, but was very much larger.—*Id. for Dec.* 6.

13. *General Chart showing the amount and yield of Mineral fuel in Austria in the year* 1868, by FR. FOETTERLE.—An interesting Chart published by the Geological Reichsanstalt of Austria, under the title, Uebersichts-Karte des Vorkommens der Production und Circulation des mineralischen Brennstoffes in der Oesterreichischen Monarchie im Jahre 1868.

14. *Rhododendreæ Asiæ Orientalis:* a paper by Maximowicz, recently issued (1870) as the 9th fasciculus of the 16th volume of the Memoirs of the Imperial Academy of Sciences of St. Petersburg; illustrated by 4 plates, imp. 4to. In the commencement of this elaborate and very interesting article, Maximowicz explains that the name *Rododendreæ* is preferred to *Rhodoreæ* because the genus *Rhodora* is a mere quasi-abnormal form of a section of *Rhododendron*, taking this genus, as he does, in the most enlarged sense. Also that the characters of scaly and not scaly buds is not completely available, as was thought, for dividing the groups into two tribes as Klotzsch proposed. We have been accustomed to use this character in a subordinate way, when it is very valuable, aware that both modes occur in some genera, such as *Vaccinium.* The main distinction between his *Phyllodoceæ* and his *Eurhododrendreæ* is that of the seed, with a close testa in the former, *scobiform* in the latter. Among the genera of the former he ranks *Rhodothamnus*, founded on *Rhododendron Chamæcistus.* The point which most nearly concerns us is that, notwithstanding the Californian species which we regard as uniting them, Maximowicz keeps up both *Bryanthus* and *Phyllodoce*, the former of Steller's original plant only, the corolla of which he newly describes as "ad basin 4-partita, horizontaliter patens." He also reclaims the genus for Steller, and states that Pallas had done so before him, that Gmelin had copied name and character *verbatim* from Steller, but without mentioning him at all. As to the genera, upon a review of the question under all the light now thrown upon it, we still think that the union proposed is likely to be maintained.

The name *Loiseleuria* is kept up,—although the plant was the original Linnæan *Azalea*,—and with sufficient reasons of history and convenience, which ought here to overbear the rule; for it is impracticable at this day to dissociate the name *Azalea* from the shrubs which every one knows under that name.

Of *Menziesia* Maximowicz recognizes six species; that is, he holds to the distinctness of our eastern *M. globularis* from the north-western *M. ferruginea* (but the characters seem to us insufficient and evanescent), finds a better distinction for the cognate Japanese species in its pentandrous flowers, and has three more apparently well-marked Japanese species.

Tsusiophyllum, of a single Japanese species, is an interesting new genus between *Menziesia* and *Rhododendron*, distinguished by its narrow tubular corolla, trimerous pistil, and longitudinally dehiscent anthers.

Rhododendron, the great genus of the group, is disposed under eight sections. Four of these are of the terminal-flowered series, all but the last of which make the innovations from separate buds: 1. *Osmothamnus*, DeCandolle's genus, to which *R. Lapponicum*, and the two *Alpenrosen*, with some related species, are added. 2. *Eurhododrendron*, comprising the typical species, under four subdivisions. 3. *Azalea* with annual leaves, answering, with some exceptions, to that genus as admitted by DeCandolle. To a group of this subgenus, otherwise all Chino-Japanese, belongs *R. Rhodora* Don. 4. *Tsusia*, of which the so-called Indian, but really all Chino-Japanese Azaleas of our conservatories are the representatives, in which the innovations come from the same terminal buds with the flowers, and the leaves are less deciduous.

The lateral-flowered series consists of those which bear single or sometimes geminate flowers from lateral scaly buds. 5. *Keysia* Nutt. is formed for a single evergreen Himalayan species. 6. *Rhodorastrum*, with annual leaves and lateral innovations has *R. Dauricum* for its principal representative. 7. *Azaleastrum*, known from the last by its almost rotate corolla, comprises our western *R. albiflorum* Hook., and one or two Chino-Japanese species. 8. The anomalous group *Therorhodion*, with similar corolla, but cleft to the base on the lower side, the innovations extending into a foliaceous bracteate raceme, consists of *R. Kamtschaticum*, which reaches Alaska, and *R. Redowskianum.*

The 8th decade of Diagnoses of new plants of Japan and Mandshuria, by the same author, reprinted from the Academy's *Bulletin*, of the autumn of 1870, is of interest as containing a key to the species of *Elæagnus*, the characters of a new Iris which Miquel had taken for our *I. cristata*, a *Triosteum* which hardly differs from *T. perfoliatum*, and a Mandshurian and a Japanese species of *Nabalus.* A. G.

15. *Flora Australiensis.*—The fifth volume of this great Colonian Flora, by Mr. Bentham, assisted by F. Müller, issued toward the close of 1870, has just been received. It comprises the last orders of *Monopetalæ*, from *Myoporineæ* to *Plantagineæ*, the *Labiatæ* being the largest family, and the *Apetalæ* from *Phytolaccaceæ* to *Proteaceæ;* the latter being of course by far the most important family, and occupying almost half of the present volume of 584 pages. In connection with this we may note the reception of the 6th volume of Ferdinand de Müller's *Fragmenta Phytographiæ* Australiæ (Melbourne, 1867–1868,) containing characters of new species and genera, revisions of various groups, etc., illustrated by lithographic plates of some of the more interesting plants; the present volume mainly devoted to *Monopetalæ* and to *Proteaceæ*, and issued in advance of the corresponding portion of the *Flora Australiensis.* Thanks to two such indefatigable laborers, Australia may soon boast of a noble and unrivalled completed Flora. A. G.

16. *Marsiliæ and Pilulariæ, revised by A. Braun.*—The *Monatsbericht* of the Berlin Academy of Sciences for August last, from p. 653 to p. 754, is occupied by Prof. Braun with a detailed account of these genera, upon which he has previously published the results of prolonged investigations. His present account is summed up in a tabular view or key to the species of both genera (in German) followed by a systematic arrangement and revision, with full synonymy, habitat, etc. The species of *Marsiliæ* now amount to 53, of which 9 are North American; and of *Pilulariæ* to 5, of which there is one, very little known, in the United States, certainly in Arkansas, probably in Georgia. A. G.

III. ASTRONOMY.

1. *Solar Eclipse of Dec.* 22.—We copy the following article on the eclipse from *Nature*, the excellent scientific weekly under the editorial direction of the astronomer, Mr. Lockyer, and published by MacMillan & Co. London, and 63 Bleecker St., New York.

Mediterranean Eclipse, 1870; by J. NORMAN LOCKYER.—Cloud in Sicily, cloud in Spain, cloud in Africa. Such at first sight might seem to be the only result of all the observations made on the eclipsed sun of 1870.

But, after all, has the oracle been silent? I think not. Dare we, however, say that the great problem of the Corona, that one among the many still outstanding difficulties which the eclipse was invoked to settle, is settled? This, perhaps, would be saying too much, but still, I think, a step in advance has been made. The oracle has spoken darkly, perhaps, but it *has* spoken.

Let me endeavor to put the question as it stood a few weeks ago as briefly as possible.

Beginning the story some few years back we find the corona, a halo of white light around the moon, with a height sometimes represented as equal to the moon's diameter, sometimes more, sometimes less, with a border *à discrétion*,—so much did the drawings vary—regarded as the solar atmosphere.

Some thought the red prominences to be mountains, other observers called them clouds.

The polariscope was brought up with a view of determining whether the corona shone by reflected light or not. The result of this new method of observation was doubtful.

In the Indian eclipse of 1868 M. Janssen, by means of the spectroscope, still another aid, determined that the prominences were masses of hydrogen gas, but there was no final word about the corona. Major Tennant observed that its spectrum was continuous. Later in the same year Dr. Frankland and myself approximately determined the pressure of the prominence gases by means of a new method and laboratory experiments, and at once stated our conviction that the extensive corona, which had been depicted and represented by Kirchhoff and others to be the solar atmosphere, must be something else. This was our idea. I cannot quote our words, for I am writing in Venice and have no copies of our paper with me.

In the American eclipse of 1869 the problem was advanced considerably, perhaps even more considerably than we can yet form an idea of, writing as we must still do doubtfully. I do not refer to the drawings, for they varied considerably, but to the observation that the light of the outer corona, like that of the prominences, gave a bright-line spectrum. But as at least some of the observers gave positions doubtfully, "near C" and "near E," I thought that the explanation was still possible which regarded the corona as of terrestrial origin; that is, which assumed it to be an appearance due to the presence of light in our own atmosphere. The problem was one of such difficulty that there seemed a possibility that, by some unexplained cause, some of the solar light might be diffused and beat out of its course, and then mixing up with the light of the chromosphere, give us a sort of continuous spectrum, with the hydrogen bright lines superposed upon it; in other words, that as the eye perceives a bright, irregular region or glare around the uneclipsed sun, an effect due to our atmosphere, so also the eye might perceive a bright, irregular region or glare around the *uneclipsed chromosphere during eclipses*, due also to our atmosphere.

One word here about the Chromosphere, the name I have given to the bright-line-giving region outside the photosphere. It has long been clear that the spectroscopic method of observing it when the sun is not eclipsed is not totally effective; that is to say, that we only see a percentage of it—perhaps only a relatively small percentage—but the glowing prominences, that is, those in which there is no evidence of the rapid motion of ejection from the sun, the ejection taking place at all angles from the line of sight, afford evidence that there is probably a layer of cooler hydrogen susceptible of being rendered visible above the ordinary level. Now as these prominences may be 5′ high, it is not unreasonable to suppose that the chromosphere may even extend to that distance, or even a little beyond it.

Hence it was that in the Instructions to Observers, drawn up by Prof. Stokes, and myself, and approved by the organizing committee for this 1870 eclipse, it is stated that—

"THE PRINCIPAL OBJECT to be obtained is to determine whether it is possible to differentiate the outer layers of irregular outline and the streamers (of the corona) from a stratum, say some 5′ or 6′ high round the sun, which may possibly be the limit of the gaseous envelopes above the photosphere."

The spectroscopic observers, therefore, were enjoined—

a. "To determine the actual height of the chromosphere as seen with an eclipsed sun; that is, when the atmospheric illumination, the effect of which is doubtless only partially got rid of by the Janssen-Lockyer method, is removed. If the method were totally effective, the C line, the line of high temperature, should hardly increase in height: but there can be little doubt that the method is not totally effective, so the increase in height should be carefully noted."

b. "To determine if there exists cooler hydrogen above and around the vividly incandescent layers and prominences."

And the polarisers—

"To examine a detached and selected part of the corona about 6′ from the limb of the sun, and say about 8′ in diameter."

Having got so far, it may be here stated that of the three means of attack, namely, the spectroscope, the polariscope and telescope, and naked eye observations, the spectroscopic method, under certain circumstances, might have been by far the most doubtful, the polariscope method coming next.

With regard to the spectroscopic observations, if we assume that no light whatever is received by and from our own atmosphere, the observations would be easily translated. A pure continuous spectrum would reveal to us solid or liquid matter in the circumsolar regions; a spectrum continuous or not containing bright lines would give us gases or vapors; the ordinary solar spectrum, with its dark lines, would indicate matter incapable of radiation itself, and therefore cool, reflecting to us ordinary sunlight. It is clear that the problem would be complicated if circumsolar matter both reflected sun light and sent us its own; and still more so if we allow that the coronal light may be partly contributed from reflections and refractions in our own atmosphere. Then we have to consider whether the light thus contributed may possibly be due to the photosphere or to the prominences, and we are landed in a maze of difficulties which need not be discussed here.

The system of sketching introduced for this eclipse is at once so simple and final that the only wonder is that it has not been introduced before. The corona must be either solar, atmospheric, or subjective, that is, more or less built up in the observer's eye, this more or less depending *cæteris paribus* upon the brilliancy of the undoubted solar portion. If at all stations, the stations being as wide apart as they have been this time, the drawings are similar, then the corona would be undoubtedly cosmical; if dissimilar, then it would either be terrestrial or subjective; and this point could and would have been settled this time, if the weather had permitted, by arranging the observers *in pairs*, that is, dealing with two observers in each place instead of a single one, and so obtaining the eye-variations.

This being premised, what is the result of the very few observations, comparatively speaking, which have been made? Before I attempt to give any idea of my answer to this question, it is only fair to myself to state that my only sources of information, up to the present time, have been conversations with some of the American members of the Sicilian expedition, a brief telegram from the members of the English party at Agosta, the Rev. S. J. Perry's communication to the *Daily News* of the 2nd instant, and an inspection of some drawings made by the officers of H. M. ships off Aci Reale. At Catania we saw a portion of the corona for 1½ seconds through a cloud, and that was all; and the day after the eclipse, before the more fortunate members of my party returned, it became my duty to proceed to Malta in H. M. S. *Lord Warden* to attend the court-martial on the officers and crew of the beautiful but unfortunate *Psyche*, in which we had been wrecked on the 15th ult., and the weather in the Mediterranean had been so bad that it was impossible to leave Malta in time to rejoin the expedition before they left for England. Of detailed information, therefore, I have none.

In the first place, then, I submit that the fact that the corona is a compound phenomenon comes out in an unmistakable way. We have first of all a ring some 5′ or 6′ high round the moon, which almost all observers have seen alike; and then we have light beyond which some observers have seen of one shape and some of another, now stellate with many rays, now stellate with few, now absolutely at rest, now revolving rapidly.

This I think to be the key-note of all the observations with which I have become acquainted. I need scarcely say that it is exactly what had been predicted.

First among the fortunate ones who observed the corona with the telescope was Prof. Watson, of Ann Arbor, who took up his station at Carlentini, and appears to have been the best favored among the Sicilian observers. From his account I gather that there was an almost perfect *shell* around the sun about 5′ high, and that outside this shell were less definite rays. What he was particularly struck with was this, that, as seen in the telescope, the rayed portion was most developed over the prominences, and as I gathered from him in one case, the rayed portion was absent as if a veil had been removed; so that he, at all events, is strongly impressed with the idea that the shell represented a true solar appendage, and that the rayed structure was due to our own atmosphere.

Next comes Mr. Brett, who, although he was not so fortunate, still was enabled to see and place on record some most interesting features, including the whole outline of the corona and even some of the protuberances. He also, as I am informed, saw the rayed portion of the corona most developed above the protuberances, the outline of the interior portion being visible, though not so strongly marked as in the case of Prof. Watson's drawing, in consequence of less favorable atmospheric conditions. I am thankful to say that the weather at Syracuse enabled Mr. Brothers to obtain some admirable photographs, which I have not yet seen. These are among the most important results of the expedition.

Next I must mention Prof. Peirce, the head of one of the American parties, who observed two miles north of Catania, at a private casino of the Marchese Sangiuliano. I believe that he also saw the shell, but of this I am not absolutely certain; but he distinctly observed that the outer corona over the prominences was rosy red, although he did not see the promicences himself. A more beautiful proof of the terrestrial nature of this portion of the corona it would be difficult to imagine: for, of course, at the sun, the hydrogen, which thus tinged it, is incapable of coloring anything, as its own light is absorbed by the transcendent brilliancy of the photosphere; while nothing would be more natural than to suppose that the light, which, in its own atmosphere, should strongly tinge anything radially illuminated, should be that of the prominences.

But the strongest proof of the variability of the outer portion and of the constancy of the inner portion is afforded by the observations made on board the small fleet attempting to save the *Pysche* off Aci Reale, where the eclipse was observed in unclouded splendor. Here were the ironclads *Lord Warden*, *Caledonia* and *Royal Oak*, and the tugs *Weasel* and *Hearty*, besides the Italian gunboat *Plebiscito*, all within a stone's throw of each other. In all the drawings, and many have been received, we have a ring 5′ or thereabouts, while the outer portion is as variable as may be. On the same deck, that namely of the flag-ship, *Lord Warden*, two drawings were made, one by Capt. Brandreth, and the other by Dr. Macdonald, F.R.S., in which the variation is so strong that one would feel inclined to acquit the atmosphere of any participation in the matter, and to relegate the whole outer corona to subjectivity alone, did not Mr. Brother's admirable photographs show both phenomena, as I am told they do. Dr. Macdonald saw eight rays arranged with perfect symmetry; Capt. Brandreth saw only two elliptical hoops crossing each other at right angles.

Capt. Cochran, of the *Caledonia*, besides the ring, saw a complicated stellate figure, the rays of nearly equal length, while Mr. Dexter, at sea between Catania and Syracuse, saw, besides the ring, *only one ray* of inordinate length.

So much for the drawings. I think that if the records of former eclipses be now examined, especially Mr. Carrington's drawing of the eclipse of 1851, and compared with the others taken at the same time, additional evidence will be gathered in favor of the compound nature of the corona, which on the evidence now before me, I consider the great teaching of the present eclipse. Our experience in Sicily seems to be similar to that of the Spanish observers, for Mr. Perry writes that, "some observed two curved rays," while the rapid degradation of light occurred at one-fifth of a solar diameter, but, so far as I know, no one in Sicily was favored with a view of the dark intervals which were observed in Spain.

There is a strange and most interesting discordance between some of the spectroscopic observations made in Sicily and Spain. At Agosta, where the totality was well visible for ten seconds, Mr. Burton detected a green line near E, with a tangential slit (distance from moon not stated). This line, which was also seen by the Italian observers, is doubtless the one recorded last year by the American astronomers, but in Spain Mr. Perry states that bright lines at C near D, *b* (or E) and F were observed 8′ away from the sun. At Syracuse, Prof. Harkness, whose telescope was moved into the various positions by Capt. Tupman, R.M.A., found the green line in all parts of the corona, so far as about 10′ from the sun, and at one point thought he detected two green lines, less refrangible than it; but at several places he saw a complete hydrogen spectrum (including C) which he attributed to prominences, until he was informed by Capt. Tupman that there was no prominence near the slit. More proofs of the terrestrial nature of this portion of the corona, I think, taken in connection with the fact that *the dark moon gave identically the same spectrum.* It would appear that there was so much atmospheric reflection in Spain, and here and there at Syracuse, that the true coronal spectrum with its line near E, the existence of which we must now accept as established beyond all question, was partially masked by the prominent spectrum with its usual well-known lines. There is one passage in Mr. Perry's interesting letter in which, if there be a misprint, as I suspect there is, an observation of great importance is recorded. It runs, "Mr. Abbay, observing at Xeres with a spectroscope of 2 prisms of 45° belonging to Prof. Young, saw the bright lines, C, D, F; and afterwards F, and a line rather more bright than F on the less refrangible side of B, C not noticed then." Now, if *b* (not B) was intended here we have sub-incandescent dydrogen mixed with the green-line-giving-substance, which may probably be a new element with a vapor density less than hydrogen.

So that roughly we might regard the chromosphere to be built up of the following layers, which are in the orders of vapor density in the case of known elements:—

X′ (new element),		Green coronal line.
Hydrogen	Sub-incandescent,	F.
	Incandescent,	C, F, near G, h.
X, (new element),		Near D.
Magnesium,		*b* and lines in blue and violet.
Sodium,		D.
Barium,		Several lines.
Iron, &c.,		Several lines including E.

The foregoing table excludes naturally the substance or substances which give bright lines in the solar spectrum, which are at times visible in the spectrum of the chromosphere. I have ventured to suggest that the substance which gives the line in the green is a new element, because invariably I have found that in solar storms the chromospheric layers are thrown up in the order of vapor density, and because all the heavier vapors are at or below the level of the photosphere itself.

With regard to the question of polarization, the parties in Sicily obtained evidence that the corona was radially polarized, though Profs. Harkness and Eastman obtained a result which they explain differently. Mr. Raynard, at Villamonda, and Mr. Peirce, Jr., north of Catania, obtained identical results in favor of strong polarization. Hence the solar corona, accepting these observations, not only radiates, but reflects solar light to us. A careful consideration of this fact, taken in connection with the possible addition of a, so to speak, terrestrial corona to its light, may enable us to account for some of the observations, both polariscopic and spectroscopic, which do not at first appear to harmonize with those to which I have referred, notably those which give a pure continuous spectrum to the corona, and which state that its light is only slightly polarized.

From what has preceded, then, we seem justified in suggesting as working hypotheses the following, which, however, more accurate information may alter, and which I offer as suggestions only, *bien entendu.*

(1.) The Solar Chromosphere extends some 5′ or 6′ from the sun (Watson and others), its last layers consisting of cool hydrogen (Mr. Abbay), and possibly a new element with a green line in its spectrum (Young, Burton, and others); which line, if it be identical with the auroral line as stated by Gould, may possibly be present in the higher regions of our own atmosphere.

(2.) Outside this stratum the rays, &c., are for the most part due partly to our own atmosphere, partly to our eyes, for their shape varies; they are seen by some at rest, by others in motion, and their spectrum is the same as that of the dark moon (Maclear).

(3.) The white light of the chromosphere above the prominences, as seen in an eclipse, is due to its strong reflection of solar light, as shown by the polariscopic observations (Ranyard, Peirce, Jr., Ladd).

(4.) The rosy tinge of the corona proper, that is of the region more than 5 or 6′ from the sun, is due to our atmosphere containing light which comes from both the higher and lower strata of the chromosphere (Peirce, Sen., Maclear, Abbay.)

2. *Appendix to the Washington Observations of* 1868.—The Superintendent of the U. S. Naval Observatory, Commodore SANDS, has published the *Appendix I to the Washington Observations for* 1868, being a catalogue of 1963 stars, and a catalogue of 290 double stars, reduced from observations made at Santiago, Chili, during the years 1850, '51, '52, by the U. S. N. Astr. Expedition, Captain Gilliss, Supdt., Lieut. McRae, Master Phelps, and Captain's Clerk, L. R. Smith, Assistants.

The observations upon which these catalogues are based were intended to constitute vol. IV of the Report of the Expedition, but no appropriation has been made for their publication in full, though the manuscript is ready for the printer.

We heartily join Prof. Harkness in his introduction to the catalogues, in expressing the hope that it may yet be possible to procure sufficient funds to complete the reductions of the observations which were to constitute vol. V, the other unpublished volume of the report. These give the positions of 27,500 stars within 25° of the south pole. If the full observations could be published, it would be preferable. If not, a star catalogue deduced from them should be accessible to astronomers. H. A. N.

3. *Professor Young on the Eclipse.*—The letter from Professor Young, of Dartmouth College, an abstract of which is published on page 156* of this volume, in a postscript to the February number, was addressed (as was not stated in the Tribune from which it was cited) to Dr. Henry Morton, President of the Stevens Technological Institute, Hoboken.

IV. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *On Spontaneous Generation;* by E. FRANKLAND.—I have repeatedly subjected various solutions for Dr. Bastian to a temperature of 150° to 156° C. in sealed vacuous tubes, in order that he might afterward submit them to a microscopical search for living organisms. The result of this search led him to conclude that living organisms had been generated from non-organized matter, whilst Professor Huxley, who examined the contents of one of the tubes, considered that no such conclusion could be drawn from his own observations. I therefore determined to repeat these experiments, operating in exactly the same manner as before in the preparation of the solutions, the sealing them up in vacuous tubes, and exposing them to a high temperature, but taking additional and much more stringent precautions against the subsequent admission of atmospheric germs into the tubes.

For this purpose four tubes of hard Bohemian glass were prepared, and about half-filled with a liquid consisting of

Carbonate of ammonia,	15 grains.
Phosphate of soda,	5 grains.
Distilled water,	1 oz.

No care was taken to exclude living germs from these ingredients, reliance being placed, for the destruction of their vitality, upon the high temperature to which they were afterwards subjected.

These tubes were carefully exhausted by means of the Sprengel pump, and hermetically sealed; they were then, on July 18, 1870, exposed for four hours to a temperature varying from 155° to 160° C. in a Papin's digester. After being allowed to cool, the digester was opened, and the tubes immediately plunged, two of them into colorless concentrated oil of vitriol, and the remaining two into a nearly colorless saturated solution of carbolic acid in water. These precautions were taken in order to avoid the possible admission of atmospheric germs through invisible cracks in the glass; such cracks, entirely invisible to the eye, are known sometimes to exist, and to be in some cases so excessively minute as to require several days for the admission of enough air to perceptibly impair a torricellian vacuum within. By keeping the tubes entirely immersed in liquids which are immediately fatal to vitality, I hoped to meet any objections that might be raised, in the event of living organisms being subsequently found in the tubes, that the germs of such organisms had gained access to the enclosed liquids through invisible fissures in the glass. On examining them when they came out of the digester, it was evident that the interior walls of the glass tubes had been corroded by the enclosed liquid, and as the tubes had stood upright in the digester, it was easy to see, by the sharp limits of the erosion, the extent to which the liquid had expanded under the influence of the high temperature to which it had been exposed.

The cylinders containing the immersed tubes were now maintained at a temperature from 60° to 75°F., and were exposed to bright diffused daylight, and sometimes to sunlight, for a period of more than five months.

The liquid in all the tubes became more or less turbid, and in some cases a small quantity of a light flocculent precipitate subsided to the bottom. On the 24th of December last two of the tubes, which exhibited the greatest turbidity, were selected for examination (one of them having been immersed in concentrated sulphuric acid, the other in the solution of carbolic acid). The vacuum was unimpaired, and the liquid in the interior formed a good water hammer. These tubes were opened in the presence of Prof. Huxley and Mr. Busk, and we submitted their contents to a searching microscopical examination with powers varying from $\frac{1}{8}$th to $\frac{1}{16}$th. Especially was the flocculent sediment in the tubes subjected to careful inspection. So far as the optical appearances presented by the sediment go, they may be appropriately described in the terms which Dr. Bastian applied to the matter found by him in a solution of like composition and similarly treated (see *Nature*, July 7, 1870, p. 200). "A number of little figure-of-eight particles, each of which was $\frac{1}{20000}''$ in diameter, were seen in active movement, even in situations where they could not have been influenced by currents. The portions of the pellicle were made up of large, irregular, and highly refractive protein-looking particles imbedded in a transparent jelly-like material. The particles were most varied in size and shape, being often variously branched and knobbed. There were also seen several very delicate, perfectly hyaline vesicles, about $\frac{1}{20000}''$ in diameter, these being altogether free from solid contents." But the movement of the particles which were observed was obviously mere Brownian motion; and many of the particles were evidently minute splinters of glass. There was not the slightest evidence of life in any of the particles. The water on the slide containing these solid matters was evaporated off, and they were treated with hot concentrated sulphuric acid, the temperature of the slide being raised to about 100° C. There was no blackening, and the rounded and dendritic bodies remained as entirely unaltered as the glass splinters. Indeed, some of the larger spheroidal bodies were evidently rounded particles of glass which had become detached from the inner walls of the tube by the corrosive action of the enclosed liquid at the high temperature to which it had been exposed in the digester.—*Nature*, Jan. 19, 1871.

2. *Statistics of Mines and Mining in the States and Territories west of the Rocky Mountains;* by ROSSITER W. RAYMOND, U. S. Commissioner in Mining Statistics. Exec. Document No. 207, 41st Congress. 806 pp. 8vo. Washington, 1870. (Government Printing Office).—This Report treats with great fulness of the conditions of Mining Industry in all the various mining regions through the States and Territories of the far west, and is evidently the result of a vast amount of judicious labor on the part of the Commissioner, Mr. Raymond. Besides its two chapters of details on the mines, their history, conditions, methods of working, expenses, etc., and general reviews of the mining regions, it has chapters on the U. S. Mining Law; Mineral Deposits; and Metallurgical Processes; and 225 pages are devoted to a very valuable and well illustrated memoir on the *Mechanical Apparatus of Mining*, by Wm. P. Blake. The volume is one of great public importance, and should have a wide distribution through the land.

3. *Fall of rain at Hilo, Hawaii (Sandwich Islands)*, lat. 19° 42′ N., long. 155° 5′ W.—The following statement of the fall of rain at a station on the Sandwich Islands, is put on record in this Journal, because the amount of rain is very remarkable, and because the number of stations within the tropics for which we have a record of the rain-fall, is quite limited. The observations were made by Rev. Titus Coan, missionary of the American Board, with a rain-gauge made by Prof. Chester S. Lyman of Yale College. The amount of rain for each day is recorded in inches and thousandths of an inch. The total amount which fell during the year was over 182 inches; and of this 90·7 inches fell in the night. The greatest amount which fell in any one month was

38·156 inches, in March. The greatest amount which fell in one day was 10·466 inches, on March 21st.

Daily Journal of Rain at Hilo, Hawaii, from August 1, 1846, *to July* 31, 1847.

	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	July
1	·134	·639	1·085		·605	·400	·360	·620	·750	·025	·065	·130
2	·285	·030	·495	·325	1·975	·810	·692	3·045	·240		·	·060
3	·149	·340	·118	·240	·450	2·285	·140	·600	·845		·260	·110
4	·201		·155	·143	·010	·965	·300	·075	1·610	·720	·205	·125
5	1·034		1·475	·465	·260	5·895	·015	·140	4·355	·055	·015	·085
6	·155		4·290	·490	·025			·400	·285		·291	·355
7	·244		·953	2·065	1·740		·024		·015	010	·165	·080
8	·039	·015	·152	3·175	·293					3·980	·125	·950
9	·352	·015	·327		1·523				1·320	3·380	·035	·625
10	·399	·253	·330	1·700	·705	·225			·080	·100	·135	·530
11	·505	·042	·100	·650	·780			·020	·765		·195	·260
12	·395	·453	·220	·082	·789		·660	·960	·655		·145	2·170
13	·209	·438	·205	·007	·390		·050	·405			·040	·970
14	·309	·120	·020	·275	·217	·110		1·910				·070
15	·275	·010	·200	·080	·093			2·080	1·730			
16	1·415	·200	·228	·805	·147			1·290	1·060		·500	
17	·390	·103	·065	2·270	·001		1·245	·775	·965		·840	
18	·555	·350		·810	·140		1·885	·045	·375		·130	·185
19	·022	·290	·005	1·025	·126		·830	·525	1·090		·265	·015
20	·346	·173	·122	·415	·035		·110	6·885	1·625		·635	·470
21	·400	·168	·031	·112	2·067	2·910	1·205	10·466	·075		·100	·325
22	·130	·228	·090		·735	2·420	·120	1·315	·390		·240	·510
23	·037	·101		·265	·228	·520	·590	·225	·435	1·500	·028	·055
24	·395	·150	·765	·805	·595	·680	·145	1·665		·050	·455	·519
25	·155	·100	·705	1·608	·525		·020	·170			·115	·105
26	·200	·100	*	·295	·090	·100	·325	1·050			·045	·155
27	·045	·010		3·565	†	1·125	·420	·350	·095	·365	·020	·070
28	·788	·235	·176	1·465	†	·050	·810	1·095	·080	·385	·135	·150
29	·613	·265	·105	1·550	†	1·505		·680	·050	·040		·085
30	·200	·135	·200	·755	†			·030	·025			·130
31	·183		·020		†	1·515		1·385				·625
	10·685	4·963	12·643	25·442	13·937	21·515	9·946	38·156	18·865	10·680	5·256	9·919

* Gauge leaked. Total, 182,007 inches. †Record of these days lost.

4. *A short course in Astronomy and the use of Globes*; by Henry Kiddle, A. M., Superintendent of Schools, New York, Author of a "New Manual of the Elements of Astronomy." New York, 1871. (Ivison, Blakeman, Taylor & Co.)—This little book, of 190 pages, beautifully printed and illustrated, contains, in concise language, an outline of the elements of Astronomy, so presented as to make it a good text book for schools, especially in the hands of teachers capable of supplementing its condensed statements and explanations with suitable oral instruction. It appears to be accurate as to facts, clear in expression as its brevity permits, and conformed, in the main, to the latest and best authorities on the matters of which it treats.

OBITUARY.

William Chauvenet, LL.D., Ex-Chancellor of Washington University, St. Louis, died in St. Paul, Minnesota, 13 Dec., 1870, at a little more than fifty years of age. He had long been in poor health, and on this account resigned his connection with the University in 1869. After traveling in the South without the restoration hoped for, he returned to St. Louis in June, and in the autumn went to St. Paul to try that climate; but his disease terminated at last in paralysis of the cerebellum. He was buried in St. Louis.

Chancellor Chauvenet was born in Milford, in northeastern Pennsylvania, and removed at an early age with his parents to Philadelphia. His father, William M. Chauvenet, was a grocer, and wished his son to succeed him in his business; he was with difficulty persuaded by his son's teacher to develop the boy's decided mathematical taste by a College course.

In 1836 he entered Yale College, and graduated with distinction in 1840. Immediately afterward he was employed under Professor Bache in taking meteorological observations at the Girard College Observatory, but resigned in 1841 to accept the position of instructor in mathematics at the U. S. Naval Asylum in Philadelphia. Shortly after, when it was proposed to found a Naval Academy at Annapolis, the measure found a warm advocate in the young Professor, and when the institution was established in 1845, he was made one of the Board of Directors, Professor of Astronomy and Mathematics, and Director of the Observatory. For the next fourteen years he was acknowledged as the chief agent in building up the Academy.

In 1859 he was elected Professor of Astronomy and Mathematics in Washington University, St. Louis, and at the same time was offered the professorship of Natural Philosophy and Astronomy in Yale College, where the chair of Mathematics had also been at his disposal a few years before. He accepted the professorship in St. Louis, and began his work there in the autumn of 1859. Three years later, on the death of his classmate, Chancellor Hoyt, the office of Chancellor of the University was also given him.

In addition to his professional labors, Chancellor Chauvenet was the author of several scientific works of recognized merit. The first was a text-book, entitled "Binomial Theorem and Logarithms." (Philad., 1843. 92 pp. 8vo). The standard character of his second work—"A Treatise on Plane and Spherical Trigonometry," (Philad., 256 pp. 8vo),—is attested by the fact that its sales were greater in 1869, nineteen years after its first issue, than in any previous year. In 1863 he published a "Manual of Spherical and Practical Astronomy," (2 vols. 8vo, pp. 708, 632, Philad.), the original and exhaustive character of which has been noticed by the late Professor Bond in this Journal, 2d series, vol. xxxvi, pp. 159, 378. His last work, on Elementary Geometry, written during his decline in health, was noticed in the last volume of this Journal.

Professor Chauvenet also furnished valuable contributions to this Journal, to Gould's Astronomical Journal, to the Proceedings of the American Association, etc. He was a collaborator in the preparation of the American Ephemeris and Nautical Almanac, for which he furnished tables for correcting lunar distances, a method of finding the error and rate of a chronometer by equal altitudes, etc.

He married, 30 Dec., 1841, Miss Catharine Hemple, of Philadelphia, who survives him with five of their six children.

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[THIRD SERIES.]

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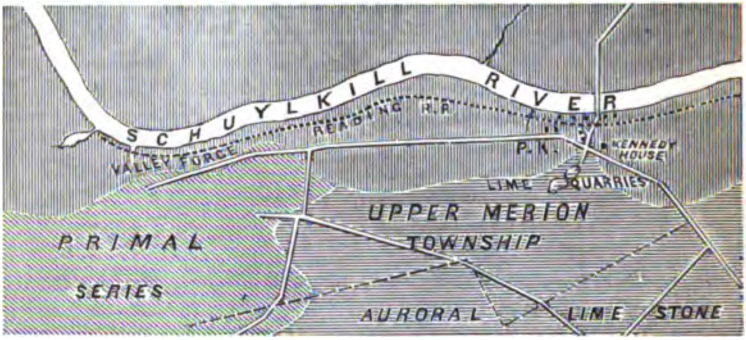
ART. XXXIII.—*Notice of the discovery of a Cave in Eastern Pennsylvania, containing remains of Post-Pliocene Fossils, including those of Mastodon, Tapir, Megalonyx, Mylodon, etc.;* by CHARLES M. WHEATLEY.

THE remains herein described were recently discovered in what was at one time a *cave*, in the limestone quarries at Port Kennedy, Upper Merion township, Montgomery county, Pa., owned by John Kennedy, Esq., to whom I am indebted for the possession of the remains, and who has afforded me every facility for exploration and investigation.

The cave is in the Auroral Limestone of Rogers, regarded as the equivalent of the Black River and Chazy Limestones and Calciferous Sand Rock of New York, at its junction with the Mesozoic Red Sandstone and near a belt of the Primal series of Rogers, (fig. 1.) Caves of more or less extent have often been met with in these quarries; but most of them have been entirely worked away in getting out the stone for lime, and, as far as ascertained, none of them communicated with the surface, or contained any organic remains.

Recently, however, in cutting through the floor of a small cave, nearly the whole of the walls of which cave had been removed for lime, the workmen found a tooth. This tooth was brought to me by Dr. Quick of Phœnixville, as a tooth of the Mastodon. In company with him I immediately visited the locality, and found one end of the cave remaining, and having the form in a transverse section exhibited in figure 2. The width at the top is about twenty feet; below, it gradually expands to thirty feet; and then there is a rapid contraction downward, until, at a depth of about forty feet (B), it is ten feet wide. The whole of the space above this level is filled with the débris of the adjoining Mesozoic red shale, with occasional angular fragments of Auroral limestone, without any trace of organic remains. Where the cave narrows to ten feet (B) the floor is composed entirely of a black clay 18 inches thick, filled with leaves, stems, and seed-vessels of Post-tertiary plants. Scattered all through this mass of vegetable remains, and also in a red tough clay underneath, for six to eight inches in depth, are found the fossils noticed in this paper.

1.



Map of the region, showing the position of the Lime Quarries and cave; area lined vertically, is region of Mesozoic red shale; horizontally, of Auroral limestone; obliquely, of Primal sandstone.

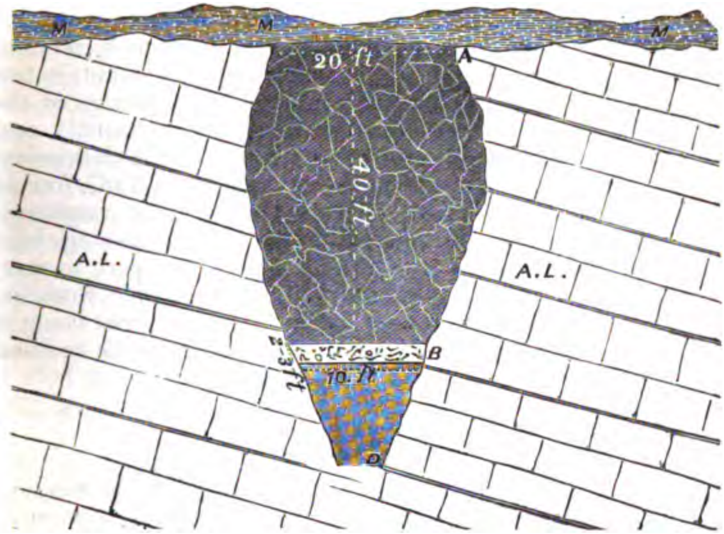
The Mastodon is *M. Americanus* of Cuvier. One of the teeth measures sixteen inches in circumference; the enamel is white or cream-colored, and well preserved. The *tusk* was uncovered for three or four feet in length, and was from five to six inches in diameter, but crumbled into fragments on being moved. The large bones are light cream color, much decomposed, but some of the articulations are very distinct.

In addition to the Mastodon and Tapir, Prof. E. D. Cope and myself have determined Sloths of the genera Megalonyx, and Mylodon, a large Artiodactyle, an Equine animal, and a large bear, the full size of the grizzly, besides other species mentioned beyond. This bear is entirely distinct in character from existing species of North America and the northern regions of the old world, as well as from the cave bear of Europe. It has been described by Leidy from a single molar from South Carolina, and if of the true genus Ursus, as is probable, will stand as *Ursus pristinus* Leidy.

The bones of Megalonyx are some of them in an excellent state of preservation; the claws and other bones of the feet especially are exceedingly perfect. Several canine and molar teeth of Megalonyx, 1½ by 1¾ inches, with the cement and crowns perfect, have been found.

Of Mylodon both bones with claws and teeth have been discovered; also teeth and bones of a large Tapirus, the teeth of which retain their white highly-polished enamel. The bones of both Mylodon and Tapirus are dark-colored, and the bone-cells usually filled with iron pyrites.

2.



Section of cave and adjoining rock; M, Mesozoic shale; A, L., Auroral limestone.

There are rodents of the existing genera *Hesperomys*, *Fiber*, *Sciurus*, *Lepus*, &c. The reptiles are serpents, tortoises and batrachians of several species. A number of Coleoptera are fortunately preserved, several of them *Carabidæ*. Several species of birds occur, including a turkey, snipe, &c.

The remains of Mylodon, Ursus and Tapirus have been mostly obtained from the tough *red* clay directly under the plant bed, but the remains of rodents, snakes, tortoises, birds, plants and insects, are entirely confined to the *plant bed*. Neither the bones or teeth are rolled or water-worn, but all are sharp and well defined.

As far as our investigations have progressed, the cave has now afforded us the following species:—

Mastodon Americanus Cuv., 1; Mylodon, 1; Megalonyx, ? 2; Tapirus, 1; Equus, 1; an undetermined ruminant; an undetermined carnivore; Ursus pristinus, and another undetermined species, 2; ? undetermined Bat; Lepus, 1; Arvicola, 1; Sciurus, 1; Fiber, 1; Hesperomys, 1; ? undetermined rodents, 2; Coluber, 2; Tropidonotus, 1; Crotalus, 1; Cistudo, 2; Rana, 1; ? Turkey, 1; Snipe, 1; making in all, 27.

Vertebrates, 27; Coleoptera, 10; Plants, 10; total, 47 species.

Phœnixville, Pa., February, 1871.

ART. XXXIV.—*On the Geology of the Delta, and the Mudlumps of the Passes of the Mississippi;* by EUG. W. HILGARD.

[Read before the American Association at its last meeting in Troy.]

IN previous papers* read before this Association, I have communicated the results obtained during two successive geological expeditions to Louisiana, so far as the more ancient formations are concerned. It is the object of the present communication to present and discuss the phenomena of that portion of the territory explored by me, lying within what is usually considered the alluvial area proper, or Delta, of the Mississippi river. Most of these observations were made in 1867, during the first of these excursions referred to, under the auspices of the Smithsonian Institution; their publication having been delayed in consequence of want of time, on my part, to carry out the large amount of chemical and microscopic work involved in the discussion, which is even yet far from being as full as would be desirable. I hope, however, to be enabled, hereafter, to continue the investigation of the subject, both in the field and in the laboratory.†

I. *The Upper Delta Plain.*

I recall to mind the fact that, as we descend the Mississippi, the older strata successively sink from view. A few miles below Vicksburg we lose sight of the older Tertiary. Thence down to the latitude of Tunica Bend, La., we find the rocks of the Grand Gulf (Tertiary) age, possessing but a very faint southward dip. Next, the oldest representative of the Quaternary epoch, viz., the stratified Drift or Orange Sand, disappears beneath the water's edge near Port Hudson; while the swamp, lagoon and fluviatile beds, which have given notoriety to the latter locality, are seen above high water level not much farther south than the city of Baton Rouge.

The gradual descent and successive disappearance of these strata is not, however, altogether a phenomenon of dip, in the usual sense, but in a great measure the result of consecutive deposition; while the *surface* slope of the Port Hudson deposits is manifestly in a great degree due to denudation, and in part, no doubt, to deposition on a sloping bottom. At Port Hudson as well as elsewhere, where extensive profiles can be seen, the deposits of that era exhibit the basin shape; both on the large and, sometimes, on the small scale. In this as well as in their lithological and paleontological features, they greatly resemble deposits now forming over large areas; and where the two are in juxtaposition, it is often difficult, sometimes impossible, to draw the line between them, since qualitatively their process of formation has been manifestly the same. Both above and below Port Hudson, and down as far as Fort St. Philip, the *apparently alluvial* river banks frequently exhibit at low water edge, solid blue clays, with cypress stumps and twigs imbedded therein, scarcely distinguishable from some materials occurring at Port Hudson, Côte Blanche, and other localities *of the Port Hudson age*; and as neither can be expected to contain any but living organisms, it is, thus far, from general considerations alone, that we can hope to deduce their real age. It might seem, at first sight, that the distinction is practically of little moment; but when it is considered that the Port Hudson deposits are separated in time from those of the present era, by a large portion of the "Champlain" period of depression, *plus* the entire "Terrace" period of elevation, it becomes obvious that the distinction is one of no little theoretical, and some practical, interest. For while the Port Hudson strata yield to the augur almost invariably a considerable rise of artesian water, no such result can usually be looked for in either river or delta deposits.

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* This Journal, II, vol. xlvii. Jan. 1869; Ibid., xlviii, Nov. 1869.

† For material assistance in the investigations embraced in this paper, I am especially indebted to the officers of the Delta Survey in charge of the Coast Survey schooner Varina—Messrs. F. P. Webber and Henry L. Marinden, for reports of observations and specimens furnished; to Capt. Day, in command of the same vessel, then moored at the Head of the Passes, for a boat's crew and personal assistance in the examination of the mudlumps; to Mr. Moulton, of the Cromwell line of steamers; to Captain Ed. Yorke, of the Towboat Association, and to Capt. Andrews, then of the dredgeboat at the Southwest pass, for free transportation on their respective vessels; and to Capt. Tilford and other gentlemen of the N. O. Pilot Association, for generous hospitality as well as much valuable information. For similar favors I am indebted to Dr. Copes, President of the N. O. Acad. of Sciences, as well as other members of that body. Other acknowledgments will be found in their proper places.

I think that a retrospective view of the geological history of the lower Mississippi Valley and Gulf Coast, as developed by my observations in the States of Mississippi and Louisiana, will serve to show the probability that by far the greater portion of what now constitutes the alluvial plain of the lower Mississippi is covered by the river deposits to a comparatively insignificant depth only; excepting where the ever shifting river channel itself has caused an unusual depth by excavation and subsequent filling up.

I have shown that toward the close of the Drift period, the place of the present Mississippi was occupied by what, but for its stupendous proportions, might be termed a torrent of fresh water, having, even as far south as the present coast line, a velocity sufficient to transport pebbles of five to six ounces weight, from localities not nearer than Tennessee and northern Arkansas; together with the smaller ones derived, doubtless, from the same sources as the drift boulders of Missouri and Illinois.*

In the bored wells of Calcasieu, these pebbles have been found as much as 450 feet below tide level; the inevitable inference being (provided the sea level remained constant), that, since the time of their transportation, the coast has suffered a depression to at least *that* extent—in matter of fact, probably, fully twice that amount.† The thickness of the drift stratum is about one hundred feet, the materials growing finer toward the top; indicating, therefore, a diminished velocity of the depositing current.

Overlying this sand and pebble drift, we find, as at Port Hudson, alternating strata of more or less lignitiferous clay and sand, 350 feet thick; a 130-foot clay bed lying on top. In its uppermost portion, this bed recalls to mind at once the variously colored clays of the Côte Blanche profile, with their calcareous concretions; but here, according to the concurrent testimony of the inhabitants and the microscope, *marine* shells take the place of the fresh-water fauna observed at the former locality. The sands which, on the whole, predominate in the lower portion, are readily distinguished under the microscope from those of the drift, by the predominant sharpness of the grains, and the occurrence of particles of lignitized wood; but I have not thus far succeeded in finding in them any other organisms. They resemble strikingly the materials obtained at corresponding depths in the bored wells in the city of New Orleans.

Few deep wells exist near the coast, in the interval between that city and the Calcasieu bores. In the only one of which I possess definite data, viz., at Salt Point on Bayou Salé, a bed of marine shells was found after passing through the first clay bed, at 60 feet.

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* Miss. Rep., 1860, p. 26 and ff.; this Journal, II, May, 1866; and Nov. 1866; Ibid. Jan.. 1869; Ibid. Nov.. 1869.

The magnitude of this phenomenon would give it a continental significance even if it were confined to what I have termed the "Orange Sand delta," below Cairo. But as I have elsewhere stated, similar pebble streams, with slack water deposits of ferruginous sands intervening, exist in Texas; and I have the satisfaction of adding to the array of facts heretofore presented in connection with this subject, the testimony of Prof. Safford, of Tennessee; who, upon discussion, finds that the phenomena presented by the "Bluff gravel," "Ore region gravel," and "Eastern gravel" of this report, are most satisfactorily accounted for, and brought under a common point of view, upon the basis set forth in my publications, above referred to.

In connection with Tuomey's and my own observations in Alabama, and farther east, those of Prof. Safford acquire additional significance, and the southern stratified drift an additional claim upon the serious attention of American geologists. Compare Prof. Newberry's interesting paper on "The Surface Geology of the basin of the Great Lakes, and the Valley of the Mississippi," where it is stated that "no deposits, corresponding to the drift of the northern and western states, exist south of the Ohio river." (Ann. Lyc. Nat. Hist., N. York, ix, 213, 1869).

† This Journal, II, Nov., 1869, p. 335.

The same is true of the formation skirting the coast of Mississippi Sound. Deep wells there sometimes, though not always, strike beds of marine shells, and water possessing a considerable rise, after penetrating the uppermost clay bed; which *there* usually also contains cypress stumps, and forms the "blue clay bottom" of the Gulf coast. Sometimes, though rarely, deposits of marine shells, of living species, appear in the beds of streams. But so far as I know, their occurrence is limited to within a moderate distance from the general coast line; so that the great body of the formation underlying the upland parishes of East Louisiana, the Attákapas and Calcasieu prairies, as well as the coast-belt of prairies in Texas, consists of marsh, lagoon, and fluviatile deposits, with, probably, many an inlet or estuary of a more or less brackish or marine character.

Obvious as is the conformation of this littoral belt to the outline of the Gulf coast, the Mississippi valley influences it only in so far, as that its strata have here, probably, their highest absolute elevation,* and farthest extension northward. The latter circumstance is the natural consequence of the existence of the depression which, at least since the opening of the Cretaceous period, has determined the outline of the formations southward of Cairo—an embayment which, with every succeeding period of deposition, became less concave, until at the close of the Grand Gulf epoch, the concavity had all but disappeared. During the period of slow depression which characterized the Port Hudson era, the present general coast line must have been established; and, when upon the reversal of the movement of subsidence, the waters of the continent began to be discharged through what is now the lower Mississippi valley, the erosion seems to have been checked everywhere, save perhaps in the main channel, by the tough cypress swamp clay which now forms the immediate substratum of the lower littoral belt, and extends far into the waters of the Gulf.

It is incredible that the deposition which occurred along the whole Gulf coast from Indianola to Mobile, should not have taken place also in the main axis of the depression which, as the trend of the formations shows, had in a great measure been filled up. Yet, inasmuch as this was the deepest portion of the area, it is to be expected that here, if anywhere, marine deposits should extend far inland. We shall not, therefore, be surprised to find that, as Pourtalés has proven from the soundings made under the direction of Gen. Humphreys, the Mississippi river flows on marine beds, at New Orleans and Bonnet Carré. It would rather be remarkable if such beds should *not* appear even much higher up the river, since even in the comparatively insignificant valley of Pearl river, they have been met with in the latitude of Baton Rouge,* about 30 miles from the coast.

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* As regards the main body. At Weeks' Island and Petite Anse, and probably at Côte Blanche and Orange Island, their elevation exceeds that at Port Hudson bluff.

It is, doubtless, owing to the formation of these swamp deposits, and their subsequent resistance to denudation during and since the Terrace epoch of elevation, that the main body of the truly alluvial delta is thrown so far beyond the general coast line,† out into the Gulf. It is the shallow "blue clay bottom," so well known to navigators on the Gulf coast, which forces the great river to advance its mouths so rapidly toward deep water, by the accumulation of its own deposits; and the borings made at New Orleans have shown how slight is the thickness, even at such an advanced point, of the river deposits proper, overlying the older formation.

I owe to the active interest taken in this subject by Gen. A. A. Humphreys, U. S. A., an opportunity of examining, not only the specimens collected during the boring of the artesian well at New Orleans by a committee of the New Orleans Academy of Sciences (so far as they were preserved from destruction during the war); but also those obtained in the soundings made by the delta survey under his charge, upon which a very able and minute report of a microscopic examination had previously been made by Mr. L. F. Pourtalés. Upon the strength of the data furnished by the latter, as well as by the profile constructed by the committee of the Academy (reproduced in the "Report on the Physics and Hydraulics of the Mississippi river"), Gen. Humphreys concluded that at Bonnet Carré and New Orleans, the river flows on an ancient sea bottom, which he conjectured to be of Tertiary age. Sir Charles Lyell having questioned the correctness of this view, Gen. Humphreys obtained from the N. O. Academy as complete a suite of specimens of the borings as could be collected, and referred them to me for examination. The first results of this investigation are given, in substance, in the first volume of Lyell's Principles of Geology, 10th edition, p. 459; they were based substantially upon the determination of the visible shells (mollusks) contained in several of the specimens, embracing, fortunately, most of the important horizons mentioned in the profile. I have since gone over the whole ground, in the microscopic examination of all the available specimens, with a view to determining their (marine or fresh water) character, and the admissibility of the supposition that they might belong to the delta formation proper.

My detailed report of this examination will, I presume, be published before long.‡ Unfortunately, most of the specimens representing the important clay strata (of 34, 32½, 39, and 63½, feet respectively), were missing; but as regards the rest, 51 in number, I found almost all derived from a lower level than 31 *feet*, either characterized by marine organizations (shells, corals or foraminifera), or of such a character as, by their obvious connection with the others, to put them in the same category, although devoid of fossils. I cannot omit to mention in this connection, the extraordinary scarcity of marine organisms in some of the specimens brought up in sounding *off*, *on* and *inside* the bars of the Mississippi passes; the most patient search, even after concentration by washing, having failed to bring to light anything but minute fragments of wood, root and other vegetable fibers, and remnants of Naviculæ. These specimens had, it is true, been obtained during a period of high water; and others, collected at corresponding points, but at a different season, showed abundance of foraminifera, and even some visible shells. But in view of these facts, it is quite intelligible how in an estuarian formation, forming at the outlet of the continental waters, many portions may have remained destitute of any vestige of marine life, though perhaps deposited in strongly brackish water; while any slackening in the rate of depression would promptly cause a predominance of the fresh over the salt water, a stagnation, and consequent deposition of clays; which would be nearly or quite free from vestiges of marine life. Such is the case in *some* of the few clay specimens from this bore, which I have had the opportunity of examining; but others I have found to contain not only foraminifera, but abundance of shells. In the clay occurring at the greatest depth reached—630 feet—Mr. Pourtalès reports an abundance of foraminifera.

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* Miss. Rep., 1860, p. 156.

† Drawn, say from the mouth of Pearl river to Belle Isle, the most advanced outpost of the Port Hudson deposits on the Louisiana coast; which line will pass near the city of New Orleans.

‡ In Rep. of the U. S. Engineer Dept., for 1870.

The specimens from the several beds contained altogether about 50 species of mollusks, of which 40 were in such a condition as to be determinable with certainty. Of these, 36 were species now living in the Gulf, and 4 were new.

The latter (belonging to the genera *Cardium*, *Abra*, *Semele* and *Tapes*) I submitted to Mr. Conrad for determination and description. He remarks that while they (one of them especially) seem to be rather of Miocene type, and not known to be now living in the Gulf of Mexico: yet our knowledge of the fauna of the latter is so imperfect thus far, that it cannot be asserted that the species are not now inhabitants of the Gulf waters.

As regards the distribution of the species, there is no material difference from the highest to the lowest level, the leading and predominant species being everywhere about the same, and coinciding in a marked manner with the fauna collected by myself on the beach of Ship Island in the Mississippi Sound;

though quite different in the prevalence of species, from that now cast ashore on the islands of the delta. One of the new species, moreover, occurs abundantly in one of the very first shell-beds; and three of them at the depth of 235 feet, as well as, in part, still lower down.

In view of all the facts bearing on the case, the most probable conclusion is that the marine formation penetrated in the New Orleans well is altogether independent of the present delta formation; that, on the contrary, it is the equivalent in time of the Port Hudson deposits, which everywhere near the coast assume a marine facies; and would necessarily possess that character in an increased degree, where the deepest depression existed.

The thickness of the alluvium proper in the alluvial plain will, of course, vary in accordance with the degree of denudation that the older formation may have experienced during the era of upheaval; and it is futile to attempt an estimate of the amount of alluvium deposited by the great river since the beginning of the modern era, until numerous observations shall have placed us in possession of data, allowing us to form an approximate estimate of its depth in the several portions of the alluvial plain. While there exist in it, doubtless, a number of ancient river channels, we already have proof also, of the existence of ridges of more solid and ancient ground, far out in the delta plain, which seem to have caused the eastward deflection (parallel to the Tèche and the main Mississippi), of Bayou Lafourche as well as of the minor channels. I have heretofore* alluded to the apparent *general* cause of this deflection, viz., the barrier of drift materials accumulated, perhaps, upon a Cretaceous nucleus, which is presented by the chain of Five Islands—Belle Isle, Côte Blanche, Weeks' Island, Petite Anse and Orange Island—extending from Atchafalaya to Vermilion Bay.

The very variable depth of the alluvium is well exemplified by the borings made for water and gas, in the City of New Orleans, by Mr. J. B. Knight, of that city. Its lower limit seems to be almost everywhere marked by a stratum of liquid mud, beneath which appears the first shell bed. It is from this mud stratum, which is struck at depths varying from 31 (in the well of 1856) to 56 feet, that combustible gas is frequently found to issue in considerable abundance, and with a pressure (as reported by Mr. Knight) of from 1½ to 3 pounds per square inch. The discovery (which was made by Mr. Knight in boring an experimental well for water, on his premises) at first created considerable excitement, as it was thought the natural gas might successfully compete with that of the gas company, which it was said to equal in quality. That this was but an indifferent compliment to the company's product, may be judged from the composition of the natural gas, which was analyzed by Prof. J. W. Mallet, then of the University of Louisiana, with the following result:

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* This Journal, II, Jan., 1869, p. 83; ibid, Nov., 1869, p. 343.

Gas from "Knight's well," 170 Gravier street, New Orleans.

Marsh gas,	91·81
Carbonic acid,	2·97
Nitrogen,	5·32
Hydrocarbons condensible by bromine,	trace
	100·00

The gas issued at the rate of one and a half cubic feet per hour, with a pressure of 1·6 inches of mercury. It was reached at a depth of 40 feet, and was accompanied by a considerable flow of faintly saline water.*

Mr. Knight sunk numerous wells in different portions of the city, and states that gas was struck nearly everywhere at depths varying from 37 to 56 feet; its amount, in one and the same region, being sensibly proportional to the diameter of the bore. In a few cases, an extraordinary amount of gas, under strong pressure, was struck. In an article published in the New Orleans Times, of March 19, 1870, it is stated that "at the old Washington Artillery building on Girod street, a pipe was driven for water, and the gas flowed through in such a volume, that when ignited it fed a flame 15 feet in height, which was with difficulty extinguished; and when it was at length choked out, it carried up several cart loads of sand in a single night. Yesterday a similar phenomenon presented itself on the edge of the sidewalk in Camp street, opposite Lafayette square. A pipe about an inch and a half in diameter had been driven into the ground for water, when at the depth of 60 feet, a rush of gas, accompanied by water and sand, was forced through to a distance (height) of twelve or fifteen feet above the top of the pipe. This continued for two hours, in spite of all efforts to suppress it; and the result was a deposit of sand mixed with fine shells and pebbles, amounting to at least three cart loads. Finally the workmen succeeded in closing the pipe, and forcing it through the gas-bearing stratum."

The supply of gas was in the end, however, thought inadequate for practical purposes; while the original object of obtaining drinkable water was attained to a limited extent only. Mr. Knight says in a letter on the subject, that he has "found great irregularity in the thickness and character of the strata, and it is impossible to tell the character of the water or the depth at which it will be found, before trying. At two places distant about 1,500 feet, I obtained, in one, at the depth of 48 feet, a free supply of clear water strongly impregnated with iron; in the other, no such water could be found at the depth of 78 feet."

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* See analysis beyond.

Attention having been called to the subject, a "find" of gas was next reported from the parish of Lafourche, said to rise with a pressure of 10 pounds to the inch. I have been unable to learn whether or not this occurrence of gas is identical with that described to me by Col. Thibodeaux, of Thibodeauxville, as keeping up a continual agitation of the waters of the "Bayou bouillant," on the lower Lafourche. So far, no practical application of this source of gas has come to my knowledge.

As regards, then, the upper delta plain, there can be little doubt that, like the Calcasieu and Attákapas prairies, it is underlaid by the detrital deposits of the stratified Drift, at a depth which may fairly, *à priori*, be supposed commensurate, in a measure, with the importance of the neighboring channels; viz., the Sabine on one hand, and the Mississippi on the other. About midway between, the Cretaceous ridge, marked by the line of outliers from Lake Bisteneau to Chicotville or Petite Anse, has caused these same deposits to appear at the surface.* The overlying swamp, lagoon and estuarian deposits of the Port Hudson age, will vary both in thickness and in the (marine or fresh-water) character of their materials, in accordance with the conformation (relative to the ocean) of the surface upon which they were deposited. And the alluvial deposits proper will, in like manner, vary in thickness in accordance with the degree of denudation previously experienced by that older formation, but appear to be little greater on the alluvial plain near New Orleans, than it is sometimes found to be in the Yazoo and Tensas bottoms.†

It is important to note that, under this point of view, the ultimate success of an artesian bore at New Orleans becomes a matter of certainty—a question of depth alone. All water obtained in the Port Hudson strata possesses considerable rise, but is usually too strongly mineral to be desirable for everyday use. The waters obtained in the Orange Sand, on the contrary, are always remarkably pure, and when struck *beneath* the Port Hudson deposits cannot fail to possess a proportionate rise, as in Dr. Kirkiman's bore, on the West Fork of Calcasieu. The waters of the Port Hudson strata would, of course, require to be tubed out.

[To be continued.]

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* This Journal, II, Nov., 1869, pp. 332, 342 and ff.

† Humphreys and Abbot's report, pp. 98–100, et al.

ART. XXXV.—*Contributions to Physics from the Lawrence Scientific School*.—No. 1. By S. P. SHARPLES, S.B.

On some forms of the Galvanic Battery.

WHILE making some experiments as to the best method of determining nitrous acid, Dr. Gibbs had his attention called to the fact that nitrous acid is instantly oxydized by an acid solution of potassic bichromate to nitric acid.

This result he communicated to me in the early part of 1870, saying, at the same time, that he thought it might be advantageous to use a mixture of nitric and sulphuric acids and potassic bichromate, as the absorbing liquid in the porous cell of the Bunsen battery. The chromic acid would prevent any evolution of nitrous acid by oxidizing it as soon as formed to nitric acid. The nitric acid being the active fluid in the combination would prevent the polarization which is continually taking place in the ordinary bichromate battery, and would be constantly renewed.

Having occasion to use a battery, a few days after, I tried the mixture with such satisfactory results that it seemed desirable that the subject should be more fully investigated. The electro-motive force and internal resistance of the battery were therefore determined.

The apparatus used was one of Poggendorff's rheostats, which was furnished with sixteen meters of German silver wire, the resistance of this being but little affected by changes of temperature. By means of clamps, any number of centimeters of wire could be introduced into the circuit. When the needle of the galvanometer was deflected to forty or fifty degrees a change of one centimeter in the length of the resistance could be readily seen. The galvanometer was an ordinary one in which the coil was replaced by a broad, thick, copper band, passing once around and close to the needle, which was suspended by a filament of silk and so adjusted that it was at the zero of the scale when it came to rest in the meridian.

In order to determine the internal resistance, I made use of two elements of the same construction, which could be thrown into the circuit either singly, or side by side. I found when all my connections were bright, that there was no appreciable difference between the two elements, that is, either element when connected with the galvanometer would deflect it the same number of degrees.

The zincs were about four inches high, and two and a half inches internal diameter, with a slit in one side. The porous cups filled the internal space almost entirely. The carbons used were those manufactured by Chester of New York for ordinary medical batteries and had a section of about a square inch. The exciting liquid was a mixture of sulphuric acid with nine times its volume of water; this was found to be without action on the zincs when the battery was not running. The zincs were kept well amalgamated.

The electro-motive force was determined by Wheatstone's method,* as follows: One of the cells was thrown into the circuit; the rheostat was then adjusted until the needle stood at 40°; the resistance was then decreased, until the needle rose to 50; the length of wire removed was noted. The second cell was then placed by the side of the first and the resistance increased until the needle again stood at 50°, and the added length of wire noted. While both cells were connected the needle was brought again to 40°, by removing part of the resistance, this length was also noted; it should correspond exactly to the first length. One of the cells was then removed and the resistance again adjusted; the wire removed should exactly equal the second length noted above. The second cell was now substituted for the first, and if the needle still remained at a constant point, the measure was considered satisfactory. If there was any discrepancy in the measurements, or if the needle stood at a different point with one cell, from what it did with the other, the connections were all examined and the measurements repeated. It was rarely found necessary to make more than one trial.

The formulas used were those given by Wheatstone (loc. cit.), as follows: For electro-motive force $\frac{E}{E'} = \frac{l}{l'}$ in which E = the electro-motive force of a standard battery, and e the length of wire necessary to reduce the needle of the galvanometer from one given point to another given point. E′ = the electro-motive force of the battery to be determined, and l' the length of wire which was required to be removed to change the needle from one of the given points to the other.

For the internal resistance of the battery, $R=2l$, in which formula $R=$ the internal resistance, and $l=$ the length of wire which must be added when a second cell is placed by the first to bring the needle to the same point where it stood when only one cell was in circuit. After making one series of measurements, the needle was brought to 40°, and allowed to remain at that point for twelve hours if the battery remained constant for that length of time; the measurements were then repeated, and compared with those of a Bunsen cell made under the same circumstances.

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* Phil. Trans., 1843, Part II, p. 313.

The first measurements, made in March, 1870, were merely to determine the electro-motive force. In the rest of the experiments, made in December, 1870, and Jan. 1871, the internal resistances were also determined.

1*st Experiment.* For purposes of comparison, a Daniell's cell was fitted up, using the same zinc and porous cup, and the same exciting liquid, but substituting for the carbon a hollow cylinder of copper open at one side and using a saturated solution of cupric sulphate as the absorbing liquid. The mean of six comparisons of this with a Bunsen's cell gave 169 for the electro-motive force of the latter, that of Daniell's being 100. Latimer Clark* gives the number 175.

Ex. No. 2. The porous cell was filled with a saturated solution of potassic bichromate in a mixture of equal parts of nitric and sulphuric acids, diluted with four times their volume of water. This gave a constant battery working without giving off acid fumes until the exciting liquid was exhausted. Its electro-motive force was the same as that of the ordinary Bunsen cell.

Ex. No. 3. The porous cell was filled with coarse fragments of potassic bichromate, and then saturated with nitric acid. The electro-motive force was the same as in the last experiment, but the battery was not quiet so constant, and there was a great waste of bichromate, there being much more than was requisite to saturate the nitric acid.

Ex. No. 4. The cell was filled as in the last experiment, only the liquid used was a mixture of equal parts, nitric and sulphuric acids. The electro-motive force was the same, but trouble was experienced from the formation of crystals of chromic alum which encrusted the carbons and porous cells and stopped the working of the battery.

Ex. No. 5. The absorbing liquid was a saturated solution of potassic bichromate in hydrochloric acid. The electro-motive force of this battery rapidly declined; starting with the same force as Bunsen's, in the course of 2½ hours it ran down to two-thirds of that force; its internal resistance at the start was 1·7 that of Bunsen's; at the end of 2½ hours it was 3·6. It gave off chlorine during the whole time it was in action.

Ex. No. 6. The absorbing liquid was a saturated solution of potassic bichromate in nitric acid. It gave the same electro-motive power as the ordinary Bunsen cell, but the internal resistance was about 2·3 as much. The battery was sensibly constant for twelve hours.

Ex. No. 7. Ex. No. 1 was repeated under slightly different circumstances. The saturated solution of bichromate, used in the last experiment, was mixed with ⅛ its own volume of strong sulphuric acid, and enough water added to take up the precipitated chromic acid. This formed the most satisfactory battery tried; it was perfectly constant during twelve hours. The internal resistance was only about 1½ times that of an ordinary Bunsen's cell of the same construction, and not the slightest odor could be perceived in the room. The electro-motive force was the same as that of the Bunsen cell.

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* On Electric Measurements, p. 108.

Ex. No. 8. Having seen in the American Chemist* a notice of a new battery by Prof. Bunsen, mentioned in an address by Prof. Roscoe, before the Chemical Section of the British Association for the Advancement of Science, I made a trial of it. This battery consisted of two metals, platinum and zinc, with a single fluid, namely, a solution of chromic acid in dilute sulphuric acid; I tried it in a small cell in which equal surfaces of zinc and carbon were opposed to each other. The electro-motive force was twice that of a Daniell's cell, or 1·2 that of a Bunsen's; but it was not very steady, and the chromic acid acted strongly on the zinc.

Ex. No. 9. Dr. Gibbs suggested to me to try a solution of chromic acid in nitric acid in the porous cell, using sulphuric acid in contact with the zinc. The electro-motive force was the same as in the last experiment, and the internal resistance was the same as in the Bunsen cell. The battery was perfectly constant. Two cells very slowly decomposed pure water and gave vivid flashes of light when the connections were made.

Ex. No. 10 was undertaken to determine the effect of replacing the bichromate by manganic oxide. The porous cell was filled around the carbon with manganic oxide; nitric acid was then poured on it until it was completely saturated. This gave very poor results; the electro-motive force was about 1·43 times that of a Daniell's cell. The battery was not very steady, and after running some time began to give off fumes of nitrous acid.

Ex. No. 11. Joule† gives an experiment with a battery in which platinum in nitric acid is used as the negative, and zinc in caustic potassa as the positive electrode, and gives the electro-motive power as equal to 2·41 Daniell's. I repeated the experiment, using a solution containing ⅕ of its weight of potassic hydrate in the outer cell, and a saturated solution of chromic in nitric acid in the inner cell. I found the electro-motive force at first about 2·35 that of Daniell's cell, the internal resistance being that of a Bunsen's cell. It was rather unsteady at first, and then began to gradually decline. No odor was perceptible.

Several experiments were tried, with the hope of obtaining a single fluid battery with the following results.

Ex. No. 12. A strong solution of caustic potassa was made, saturated with ferricyanide of potassium and used in the cell employed in experiment No. 8. This gave a feeble current and the carbon was rapidly polarized.

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* Vol. i, p. 209.

† Phil. Mag., vol. xxiv, p. 113, 1844.

Ex. No. 13. As solutions of sulphurous acid and acid sulphites dissolve zinc without evolution of hydrogen, forming hyposulphites, it was thought that these might be used as the exciting liquids. They gave a very feeble current and the carbon was soon polarized; the sulphite of zinc formed also adhered to the zinc and prevented further action.

Ex. No. 14. Iodide of potassium saturated with iodine was tried; this also gave a feeble current and the carbon soon became polarized.

Ex. No. 15. A cell of the Maynooth battery was fitted up and a saturated solution of potassic bichromate in nitric acid used as the absorbing liquid; the battery was not very constant, and the iron was soon attacked; no fumes, however, were given off The electro-motive power was about ·55 of a Daniell's cell.

The result of these experiments seem to show that the battery used in experiment No. 7 is the best for ordinary use, since it costs but little, if any more, than the Bunsen battery charged with nitric acid alone, and is entirely free from fumes until exhausted. If the following directions are observed in preparing the fluids, it cannot fail, I think, to give satisfaction.

To prepare the exciting liquid, sulphuric acid of 1·84 sp. gr. is mixed with nine times its volume of water and allowed to stand until the precipitated lead has all settled. The clear acid is then decanted and is fit for use. This plan of preparing the acid has been in use in this laboratory for some years and gives very good results, local action being almost entirely prevented by the removal of the lead.

To prepare the absorbing fluid, ordinary commercial nitric acid is saturated with potassic bichromate; this should be done in a warm room, as it takes up much more when warm than when cold. The solution thus prepared is mixed with one-third of its volume of sulphuric acid and enough water added to re-dissolve the chromic acid precipitated.

Two objects are gained by adding the sulphuric acid. The mixture is less expensive than if pure nitric acid is used and the internal resistance is decreased. If the internal and external cells are properly proportioned this battery will run until the exciting fluid is exhausted, without giving off any fumes of nitrous acid. If crude chromic acid could be obtained at a sufficiently low rate, No. 9 would be a very powerful and convenient battery for many purposes.

My thanks are due to Dr. Wolcott Gibbs for many valuable suggestions made during the progress of this investigation and for the use of the apparatus employed.

Cambridge, Jan. 17, 1871.

ART. XXXVI.—*Notes on the Geology of Santa Domingo;* by WM. M. GABB.

ALTHOUGH the geological survey of the Republic of Santa Domingo has now been in progress about two years, nothing has been made public of our results, and I had not intended to publish anything until its completion. But circumstances now transpiring render it advisable that I should put on record at least a sketch of the principal conclusions arrived at.

The Republic is of a very irregular triangular shape, nearly twice as long east and west as from north to south. The total area is about 20,000 square miles. Running nearly through the middle, with a direction a little south of east, is a high chain of mountains, some peaks reaching a height of 9,000 feet. This range falls to the eastward, forming ultimately a chain of hills which runs parallel with the southern border of Samaná bay. In some places it is hardly ten miles wide, in others (near the middle) it reaches a width of nearly forty miles, including its greater spurs. South of this range, bordering the coast, is a tract, partly of rolling hills, partly of plains, which, especially in the large peninsula at the eastern end, constituting the Province of Saybo, are broad grassy prairies, cut up by lines of trees, filling depressions and bordering water courses.

Parallel with this great range and bordering the north coast is another mountain chain, neither so broad nor so high as the first. This extends from Manzanilla bay, almost on the Haytien frontier, to the extreme end of Samaná peninsula. It is cut through, near the head of Samaná bay, by a narrow belt of marsh land, through which runs a salt water creek, thereby making Samaná really, an island. This range has a few peaks rising to 2,500 or 3,000 feet and is nowhere much over ten miles wide. Between the two mountain chains lies a long valley having an average width of ten or fifteen miles, in some places much wider, in others, encroached on by the foot-hills of the mountains on its south. The valley is divided near its middle by a water-shed, but 500 feet above the sea. The Yaqui and Yuna rivers, rising in the higher hills south, run through this valley, the former emptying into Manzanilla bay on the west, the latter into Samaná bay on the east. On the south side of the island are several large rivers which run from the same mountain southward. The principal of these are the Macorio, Ozama, Jaina, Nigua, Nizao, Ocoa and Neyba, the last sometimes called the Yaqui of the south, rising in the same peak as its northern namesake.

Having thus described the leading topographical characteristics as concisely as possible, we can more easily explain the geological features which are intimately connected with them.

The great central chain of mountains consists of an immense cone of syenite and syenitic rocks, evidently of later date than the metamorphic strata that flank it. This mass is probably, in some places, as much as fifteen or twenty miles wide, though its southern and southwestern borders have not yet been explored, lying as they do in the Province of Azua, to which our labors have not yet extended. In this Republic it makes its appearance on the borders of Hayti, about fifteen miles south of Manzanilla bay, and from here makes all of the higher range of central mountains, to a point just about due northwest of Sta. Domingo City, or in other words, the center of the Republic; there its northern boundary suddenly bends south, becoming the eastern, the mass making a tongue eighteen to twenty miles wide, running a little east of south, to a point about twenty miles from the coast and nearly north of Bani. From analogical reasoning, based on the character of its northern margin and the peculiarities of the topography, it is almost safe to predict, that north of Banica and San Juan, or in other words in the mountains of the north-west, it will not have a much greater width than the strip above Bani. This mass of crystalline rocks has pushed up, tilted, folded, and in some places sent complicated net works of dikes into the overlying strata. Some of the dikes extend miles from the parent mass, and are of all sizes from 100 feet and upward, down to a thread.

The lithological characters of the syenites are not so variable as might be anticipated over so wide an area (say 20 by 100 miles). The rock is usually a light gray, moderately fine-grained mixture of the ordinary constituents, quartz, feldspar and hornblende, in nearly equal proportions, though sometimes the latter mineral makes up almost the entire mass, in the shape of large crystals, and more rarely it is almost entirely absent, and still more rarely a little mica occurs. No gneiss has been observed, but two or three localities of mica slate have been found, and one or two erratic pebbles have been discovered composed of quartz and feldspar only.

Overlying the syenite, and as stated above, uptilted by it is a heavy deposit, several thousand feet thick, of conglomerates, jaspery and magnesian slates, with a little limestone. These are almost invariably metamorphosed to such an extent as to have entirely destroyed their original character, and often, even their stratification. In the country west of Bani, both about the lower Ocoa and farther north, the shales are so little altered that they can be recognized as fissile clay shales, in a few cases giving rise to salt springs, but in no case fossiliferous. I was fortunate enough, at one locality on the Nigua, to discover a small locality in the limestone, almost unaltered and with a few fossils, usually poorly preserved. I succeeded in obtaining a little *Ammonite*, a *Trigonia*, a *Pterocardia* shell, besides a few less characteristic genera, and what may prove to be a *Baculite!*; thus fixing the secondary and possibly the Cretaceous age of the oldest stratified rocks on the island.

These rocks form a border to the crystalline cone, and extend to the eastern end of the island forming its "backbone." On the borders of the syenite, it is often cut by veins of auriferous quartz, and elsewhere it contains unimportant deposits of copper, and in one locality, iron.

In the neighborhood of San Cristobel, twenty miles west of Sta. Domingo, and extending as far west as we have explored, are small isolated basins of the next formation. This obtains its greatest development on the north side, but is said also to fill a depression extending to Port au Prince. I refer to the Tertiary rocks, which play an important part in the geology of the Island. They lie unconformably on the edges and flanks of the secondary deposits, fill all of the great northern valley of the Citao, and constitute the northern chain. In the northern foot-hills of the central chain, these rocks come in as a thin edge, gradually thickening as we descend into the valley, and eventually acquire a thickness of perhaps 1,500 or 2,000 feet. They consist of conglomerates, sandstones, gray, blue, brown and white shales, argillaceous and pure limestones, the rocks being enumerated in an ascending series from the conglomerates upward. Fossils are found throughout the series, though usually rare except in the blue and brown shales where they are sometimes very abundant, and in an extraordinarily beautiful state of preservation. There have been enough fossils found in all the beds, from base to top, to settle the question, that no line of demarcation of age can be drawn in the series. The species have not been sufficiently studied, by me, to enable me to express a positive opinion as to the part of the Tertiary group to which they belong. Messrs. Geo. Sowerby (Quart. Jour. Geol. Soc., London, 1849, p. 44), and J. Carrick Moore, (*loc. cit.* and Quart. Jour., 1853, p. 129), consider them, for good reasons given, to be Miocene, in which opinion I am inclined to concur; while Mr. T. A. Conrad, whose acquaintance with the American Tertiaries is greater than that of any other person, says they are Oligocene.

In the valley of the Cibao these beds are but little disturbed, at most being but slightly undulated; but in the northern range of mountains they are in some places highly uptilted, in one locality being vertical, but were much folded. The coal mines reported to exist in Sta. Domingo are merely the beds of lignite in the shales of this group.

It is proper here to call attention to an article in the Quart. Jour. Geol. Soc. 1853, p. 115, *et seq.* by a Mr. T. S. Heneken, illustrated by a map and several sections. I do so because the above description is totally at variance with the article quoted, and these examinations were made with a full knowledge of the statements of Mr. Heneken. I make this explanation, not from any feeling of antagonism, and may mention that the author died several years ago on this island; but a regard for truth requires me to state that the descriptions there given of the geology of the Cibao are, at least, very extraordinary. Among other things, he has taken a part of the Tertiary sandstones, erected them into an older formation, and states, incorrectly, that it underlies unconformably the blue fossiliferous shales. Another important inaccuracy is his assertion that the north range, at Mt. Muraso, is an anticlinal of older rocks (see fig. 3, p. 119, *loc. cit.*); whereas it is really the newer part of the Tertiary deposit, lying at low angles, the anticlinal being far north of the summit of the mountains. The errors arose without doubt from the inexperience of the observer.

Bordering almost the entire coast, from Manzanilla bay, around the eastern end of the island to the north of the Nizao river, on the south side, is a deposit of horizontal limestone of very modern origin, in places full of living corals and very imperfect casts of living species of mollusca, but more usually, where not hardened by the weather, a white or cream-colored friable limestone, the result of the breaking down or decomposition of coral. It rarely makes bluffs on the coast of more than 20 or 30 feet in height, but has been penetrated by wells between 150 and 200 feet deep without passing through it. This border has a variable width of from a few hundred yards to many miles, and in the neighborhood of Sta. Domingo City, where it is a dozen miles wide, it illustrates beautifully the phenomenon of change in lithological character of the same beds. Toward its margins in this vicinity near what was at that epoch the mouth of the Jaina river, a few pebbles begin to appear, unmistakably attributable to the hills of the upper Jaina. Proceeding northward, or toward the former coast, these pebbles become more numerous and the lime less pure, until eventually the same stratum can be traced into a common shore gravel, evidently the product of the river, and without a perceptible trace of lime. Further; in going east from the neighborhood of the Jaina, but along the ancient coast, the pebbles again disappear and the shore margin of the deposit becomes, as might be anticipated, sand; while farther out the limestone belt continues in the position of the former reef.

No volcanic rocks have been encountered in the course of our explorations except in the mountains north of Bani, where we found a single dike of black porphyry with large white crystals of feldspar.

ART. XXXVII.—*On Spore-cases in Coals;* by J. W. DAWSON, LL.D., F.R.S.

WHEN in London, last spring, Prof. Huxley was kind enough to show me some remarkably beautiful slices of coal mounted by his assistant, Mr. Newton, and showing with great distinctness multitudes of spore-cases and spores, some of them very well preserved. He farther stated to me his belief that such material had been largely or mainly instrumental in the production of Coal. At the time I declined to accept this conclusion, on the ground that the specimens probably represented layers of coal exceptionally rich in spore-cases; and that even in these specimens a large quantity of matter was present which long experience in the examination of coals enabled me to recognize as cortical or epidermal matter, which I had previously shown by my examination of the coals of Nova Scotia to be the principal ingredient in ordinary coal. I promised, however, on my return to Canada, to look over my series of preparations of coal, with a view to the occurrence of spore-cases, and also to make trial of the somewhat improved method of preparation employed by Mr. Newton. On my return I gave the results of my examination to Prof. Huxley, in a letter which he has quoted in the brilliant exposition of his observations and conclusions in the Contemporary review for November,* and which will probably give a tone to the representations of popular writers on this subject for some time. While, however, admitting the great interest and importance of Prof. Huxley's observations, and prepared to contribute some additional illustrations of the occurrence of spore-cases in coal, I think it well to direct attention anew to the actual composition of the substance, as proved by its mode of occurrence, and illustrated by my own extensive series of observations on the coals of Nova Scotia and Cape Breton, including the series of eighty-one seams exposed at the South Joggins, the whole of which I have examined *in situ* and under the microscope.

The occurrence of bodies supposed to be spore-cases in coal, is, as Prof. Huxley states, no new discovery; but in reality these may be said to be the first organisms recognized by any microscopic observer of coal—that is, if all the clear spots and annular bodies seen in slices of coal are really spore-cases. They were noticed by Morris as early as 1836, and they had been observed and described long before by Fleming in Scotland. Goeppert mentioned and figured them in his "Treatise on Coal" in 1848. Balfour described them in 1859 as occurring in Scottish coals, and Quekett figured them in his account of the

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* In the quotation the word "cubical" has been substituted for "cortical."

Torbane Hill mineral in the same year. In 1855 the latter microscopist showed me in London slices exhibiting round bodies of this kind, very similar to those now described by Huxley; but at that time I regarded them as concretionary, though Prof Quekett was disposed to consider them organic. Mr. Carruthers has summed up most of these facts in his account of his genus Flemingites in the Geological Magazine for October, 1865. The subject has also attracted the attention of microscopists in connection with the Tasmanite, or "white coal" of Tasmania, which is composed in great part of the spore cases of ferns.

I suppose that the oldest spore-cases known are those described by Hooker from the Ludlow formation of the Upper Silurian; but these, if really spore-cases, are different in structure from those ordinarily found in the coal-formation, more especially in the great thickness of their walls, and I am not aware that they have anywhere been found in considerable quantities.

The oldest bed of spore-cases known to me, is that at Kettle Point, Lake Huron. It is a bed of brown bituminous shale, burning with much flame, and under a lens is seen to be studded with flattened disc-like bodies scarcely more than a hundredth of an inch in diameter, which under the microscope are found to be spore-cases, slightly papillate externally, and with a point of attachment on one side and a slit more or less elongated and gaping on the other, figs. 1, 2, 3. I have proposed for these bodies the name *Sporangites Huronensis*. When slices of the rock are made, its substance is seen to be filled with these bodies, which, viewed as transparent objects, appear yellow like amber, and show little structure, except that the walls can, in some cases, be distinguished from the internal cavity, and the latter may be seen to inclose patches of flocculent or granular matter. In the shale containing them there are also vast numbers of rounded translucent granules which may be the escaped spores.

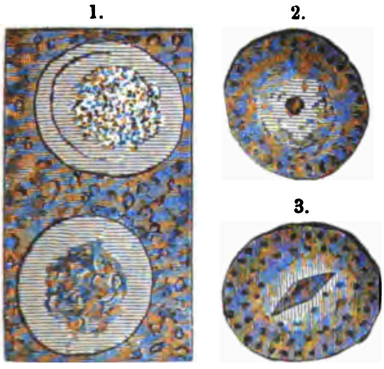

Fig. 1, Part of a slice of shale from Kettle Point, showing two spore-cases and remains of spores. 70 diameters. Figs. 2 and 3, Spore-cases from the same, as opaque objects. 70 diameters.

The bed at Kettle Point is stated in the report of the Geological Survey to be 12 to 14 feet in thickness; but to what degree either in its thickness or horizontal extent it retains the characters above described, I do not know. It belongs to the Upper Devonian, being supposed to be a representative of the Genesee slates of New York. It contains stems of *Calamites inornatus* and of a *Lepidodendron*, obscurely preserved, but apparently of the type of *L. Veltheimianum*, and possibly the same with *L. primævum* of Rogers. The spore-cases are not improbably those of this plant, or of the species *L. Gaspianum*, which belongs to the same horizon, though not found at this locality. The occurrence of this bed is a remarkable evidence of the abundance of Lycopodiaceous trees, whose spores must have drifted in immense quantities in the winds, to form such a bed. It is to be observed, however, that this is not a bed of coal, but a bituminous shale of brown color, and with pale streak, no doubt accumulated in water, and even marine, since it contains *Spirophyton** and shells of *Lingula*. In this it agrees with the Australian Tasmanite, which, though composed in great part of spore-cases of Ferns, is, as I am informed by Mr. Selwyn, an aqueous deposit, containing marine shells.

There is, however, one bed of true coal known in the Devonian of Eastern America, that of Tar Point, Gaspé, and it is curious to observe that this is not composed of spore-cases, but of successive thin layers of rhizomata and stems of *Psilophyton*, with occasional fragments of *Lepidodendron* and *Cyclostigma*. Rounded disks, which may be spore-cases, occur in it, but very rarely. In the bituminous shales associated with this coal, the microscope shows amber-colored flakes of irregular form, but these are easily ascertained to be portions of the epidermis of Psilophyton, or of the chitinous crusts of crustaceans which abound in these beds.

Ascending to the Lower Carboniferous (sub-carboniferous), there are great quantities of rounded spore-cases of the size of mustard seeds (*Sporangites glabra* of my papers) in the rocks of Horton Bluff and Lower Horton, Nova Scotia. They are sometimes globular, and filled with pyrite of a granular texture which perhaps represents the original cellular structure or the microspores. In other cases they are flattened and constitute thin carbonaceous layers. They are almost without doubt the spore-cases of *Lepidodendron corrugatum*, which abounds in the same beds, and constitutes in one place a forest of erect stumps. I described them in a paper on the Lower Carboniferous of Nova Scotia in the Proceedings of the Geological Society of London for 1858, though not then aware of their true nature, which was, however, recognized by Dr. Hooker in some specimens which I had sent to London.

In my paper on the conditions of accumulation of Coal, (Proceedings of Geological Society of London, May, 1866), I proposed the name *Sporangites* for these bodies, in consequence of the difficulty of referring them certainly to any generic forms. Carruthers had in Oct. 1865, described a cone containing rounded spore-cases of not dissimilar type, under the name *Flemingites.* In the paper above referred to, I stated that out of eighty-one coals of the South Joggins Section examined by me, I recognized these bodies and other fruits or Sporangia, in only sixteen; and of these only four had the rounded Lycopodiaceous spore-cases similar to those of Flemingites. These are the following:—

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* The well known *Cauda-galli* fucoid.

(1.) Coal group 12, of Division IV, has a bed of coal one foot thick, of which some layers are almost wholly composed of *Sporangites papillata.*

(2.) Coal group 13, Div. IV, has in some layers great quantities of *Sporangites glabra*, especially in the shaly part of the coal.

(3.) In Coal group 14, Div. IV, a shaly parting contains great numbers of similar Sporangites.

(4.) In Coal group 15*a*, Div. IV, the shaly roof abounds in sporangites, but I did not observe them in the coal itself.

In addition to these cases, all of which curiously enough occur in one part of the section, and among the smaller coals, I have noted the occurrence of clear amber spots in several of the compact coals, but I did not regard these as certainly organic, suspecting them to be rather concretionary or segregative structures.

The great coal beds of Pictou are, in so far as my observation has extended, remarkably free from indications of spore-cases, and consist principally of cortical and ligneous tissues with layers of finely comminuted vegetable matter. A layer of cannel, however, from a bed near New Glasgow has numerous flattened amber-colored discs, which may be of this character. In those of Cape Breton, the yellow spore-case-like spots are much more abundant; but these coals I have less extensively examined than those of the mainland of Nova Scotia. Of American coals, the richest in spore-cases, that I have seen, is a specimen from Ohio, which contains many large spore-cases, and vast numbers of more minute globular bodies apparently macrospores. It quite equals in this respect some of the English coals referred to by Huxley, (fig. 4). I have also a specimen of anthracite from Pennsylvania, full of spore-cases, some of them retaining their round form and filled with granular matter which may represent the spores.

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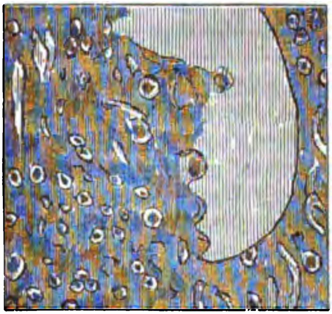

Fig. 4. Part of a slice of Ohio coal, showing at one side a part of a large spore-case, and numerous spores. 70 diameters.

It is not improbable that sporangites or bodies resembling them, may be found in most coals; but the facts above stated indicate that their occurrence is accidental rather than essential to coal accumulation, and that they are more likely to have been abundant in shales and cannel coals, deposited in ponds or in shallow waters in the vicinity of Lycopodiaceous forests, than in the swampy or peaty deposits which constitute the ordinary coals. It is to be observed, however, that the conspicuous appearance which these bodies and also the strips and fragments of epidermal tissue, which resemble them in texture, present in slices of coal, may incline an observer, not having large experience in the examination of coals, to overrate their importance, and this I think has been done by most microscopists, especially those who have confined their attention to slices prepared by the lapidary. One must also bear in mind the danger arising from mistaking concretionary accumulations of bituminous matter for sporangia. In sections of the bituminous shales accompanying the Devonian coal above mentioned, there are many rounded yellow spots, which on examination prove to be the spaces in the epidermis of Psilophyton through which the vessels passing to the leaves were emitted. To these considerations I would add the following, condensed from my paper above referred to, in which the whole question of the origin of coal is fully discussed.*

(1.) The mineral charcoal or "mother coal" is obviously woody tissue and fibers of bark; the structure of the varieties of which and the plants to which it probably belongs, I have discussed in the paper above mentioned.

(2.) The coarser layers of coal show under the microscope a confused mass of fragments of vegetable matter belonging to various descriptions of plants, and including, but not usually largely, sporangites.

(3.) The more brilliant layers of the coal are seen, when separated by thin laminæ of clay, to have on their surfaces the markings of Sigillariæ and other trees, of which they evidently represent flattened specimens, or rather the bark of such specimens. Under the microscope, when their structures are preserved, these layers show cortical tissues more abundantly than any others.

(4.) Some thin layers of coal consist mainly of flattened layers of leaves of *Cordaites* or *Pychnophyllum*.

(5.) The Stigmaria underclays and the stumps of Sigillaria in the coal roofs equally testify to the accumulation of coal by the growth of successive forests, more especially of Sigillariæ. There is on the other hand no necessary connection of sporangite beds with Stigmarian soils. Such beds are more likely to be accumulated in water, and consequently to constitute bituminous shales and cannels.

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* See also Acadian Geology, 2d edit., pp. 138, 461, 493.

(6.) Lepidodendron and its allies, to which the spore-cases in question appear to belong, are evidently much less important to coal accumulation than Sigillaria, which cannot be affirmed to have produced spore-cases similar to those in question, even though the observation of Goldenberg as to their fruit can be relied on; the accuracy of which, however, I am inclined to doubt.

On the whole then, while giving due credit to Prof. Huxley and those who have preceded him in this matter, for directing attention to this curious and no doubt important constituent of mineral fuel, and admitting that I may possibly have given too little attention to it, I must maintain that Sporangite beds are exceptional among coals, and that cortical and woody matters are the most abundant ingredients in all the ordinary kinds; and to this I cannot think that the coals of England constitute an exception.

It is to be observed, in conclusion, that the spore-cases of plants, in their indestructibility and richly carbonaceous character, only partake of qualities common to most suberous and epidermal matters, as I have explained in the publications already referred to. Such epidermal and cortical substances are extremely rich in carbon and hydrogen; in this resembling bituminous coal. They are also very little liable to decay, and they resist more than other vegetable matters aqueous infiltration; properties which have caused them to remain unchanged and to resist the penetration of mineral substances more than other vegetable tissues. These qualities are well seen in the bark of our American white birch. It is no wonder that materials of this kind should constitute considerable portions of such vegetable accumulations as the beds of coal, and that when present in large proportion they should afford richly bituminous beds. All this agrees with the fact, apparent on examination of the common coal, that the greater number of its purest layers consist of the flattened bark of Sigillariæ and similar trees, just as any single flattened trunk imbedded in shale becomes a layer of pure coal. It also agrees with the fact that other layers of coal, and also the cannels and earthy bitumens appear, under the microscope, to consist of finely comminuted particles, principally of epidermal tissues, not only from the fruits and spore-cases of plants, but also from their leaves and stems. The same considerations impress us, just as much as the abundance of spore-cases, with the immense amount of the vegetable matter which has perished during the accumulation of coal, in comparison with that which has been preserved.

I am indebted to Dr. T. Sterry Hunt, for the following very valuable information, which at once places in a clear and precise light the chemical relations of epidermal tissue and spores with coal. Dr. Hunt says—"The outer bark of the Cork tree and the cuticle of many if not all other plants consists of a highly carbonaceous matter, to which the name of *suberin* has been given. The spores of Lycopodium also approach to this substance in composition, as will be seen by the following, one of two analyses by Duconi,* along with which I give the theoretical composition of pure cellulose or woody fiber, according to Payen and Mitscherlich, and an analysis of the suberin of Cork, from *Quercus suber*, from which the ash and 2·5 per cent of cellulose have been deducted.†

	Cellulose.	Cork.	Lycopodium.
Carbon,	44·44	65·73	64·80
Hydrogen,	6·17	8·33	8·73
Nitrogen,	——	1·50	6·18
Oxygen,	49·39	24·44	20·29
	100·00	100·00	100·00

This difference is not less striking when we reduce the above centesimal analyses to correspond with the formula of cellulose, $C_{24}H_{20}O_{20}$ and represent Cork and Lycopodium as containing 24 equivalents of carbon. For comparison I give the composition of specimens of Peat, Brown Coal, Lignite, and Bituminous Coal.‡

Cellulose,	$C_{24}\ H_{20}\ O_{20}$
Cork,	$C_{24}\ H_{18\frac{2}{10}}\ O_{6\frac{7}{10}}$
Lycopodium,	$C_{24}\ H_{19\frac{4}{10}}\ N O_{5\frac{6}{10}}$
Peat, (Vaux),	$C_{24}\ H_{14\frac{4}{10}}\ O_{10}$
Brown Coal, (Schröther),	$C_{24}\ H_{14\frac{3}{10}}\ O_{10\frac{6}{10}}$
Lignite, (Vaux),	$C_{24}\ H_{11\frac{3}{10}}\ O_{6\frac{4}{10}}$
Bituminous Coal, (Regnault),	$C_{24}\ H_{10}\ O_{8\frac{3}{10}}$

It will be seen from this comparison that, in ultimate composition, Cork and Lycopodium are nearer to Lignite than to woody fiber; and may be converted into coal with far less loss of carbon and hydrogen than the latter. They in fact approach closer in composition to resins and fats than to wood, and moreover like those substances repel water, with which they are not easily moistened, and thus are able to resist those atmospheric influences which effect the decay of woody tissue."

I would add to this only one further consideration. The nitrogen present in the Lycopodium spores no doubt belongs to the protoplasm contained in them, a substance which would soon perish by decay; and subtracting this, the cell-walls of the spores and the walls of the spore-cases would be most suitable material for the production of bituminous coal. But this suitableness they share with the epidermal tissue of the scales of strobiles, and of the stems and leaves of Ferns and Lycopods; and above all with the thick corky envelope of the stems of Sigillariæ and similar trees, which as I have elsewhere shown,* from its condition in the prostrate and erect trunks contained in the beds associated with coal, must have been highly carbonaceous and extremely enduring and impermeable to water. In short, if instead of "spore-cases," we read "epidermal tissues in general, including spore-cases," all that Huxley has affirmed will be strictly and literally true, and in accordance with the chemical composition, microscopical characters and mode of occurrence of coal. It will also be in accordance with the following statement, which I may be pardoned for quoting from my paper on the Structures in Coal, published in 1859.

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* Liebig and Kopp, Jahresbuch, 1847–48.

† Gmelin, Handbook, xv, 145.

‡ Canadian Naturalist, vi, 253.

"A single trunk of Sigillaria in an erect forest, presents an epitome of a coal-seam. Its roots represent the Stigmaria underclay; its bark the compact coal; its woody axis, the mineral charcoal; its fallen leaves (and fruits), with remains of herbaceous plants growing in its shade, mixed with a little earthy matter, the layers of coarse coal. The condition of the durable outer bark of erect trees concurs with the chemical theory of coal, in showing the especial suitableness of this kind of tissue for the production of the purer compact coals. It is also probable that the comparative impermeability of the bark to mineral infiltration, is of importance in this respect, enabling this material to remain unaffected by causes which have filled those layers consisting of herbaceous materials and decayed wood, with pyrites and other mineral substances."

ART. XXXVIII.—*On a method of fixing, photographing and exhibiting the Magnetic Spectra;* by ALFRED M. MAYER, Ph.D.

THE figures produced in iron-filings, when these are set in momentary vibration on a surface placed over a magnet, have received considerable attention from natural philosophers. The geometrical discussion of these spectra made by Lambert, Roget and others, have developed their symmetrical properties, and thereby have evolved the law of that action which emanates from the magnet. De Haldat has used them as a means of exploring the distribution and intensity of the effect of juxtaposed magnets variously arranged. But, above all, have the researches of Faraday and W. Thomson on "the magnetic field" and on "the lines of magnetic force" given to these spectra—even when merely regarded as conventional symbols—an importance which has been fully shown; especially by Faraday, who was guided by their consideration to some of his most important discoveries. They have thus risen to so high a theoretical importance that a method which will fix them without danger of distortion, photographically reproduce them and readily serve to exhibit them to the largest audiences, will, I imagine, be acceptable to both investigators and lecturers.

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* Vegetable structures in Coal, Journ. Geol. Soc., xv, 626. Conditions of Accumulation of Coal; ib. xxii, 95. Acadian Geology, 197, 464.

† See a neat "Démonstration par le calcul des courbes magnétiques de la loi de l'inverse du carré de la distance," by M. Cellerier, published as a note on p. 592, vol. I of De la Rive's Traité d'Électricité.

The only process of fixing these spectra, known to me, is that practiced by De Haldat and Faraday, which, however, is but an application to the magnetic spectra of the method previously invented by Savart for preserving the Chladni figures of vibrating plates. In this process the spectra, produced in the usual manner either on glass or card-board, have pressed upon them a sheet of paper coated with mucilage, to which the filings adhere. In this operation of the transfer many particles are deranged from their positions and the figures are yet more distorted by the shrinkage of the wet paper, and are therefore not fit to serve in measures of precision; while the impressions cannot be exhibited with much more facility than the originals.

My process is as follows: a clean plate of thin glass is coated with a firm film of shellac, by flowing over it a solution of this substance in alcohol,* in the same manner as a photographic plate is coated with collodion. After the plate has remained a day or two in a dry atmosphere, it is placed over the magnet, or magnets, with its ends resting on slips of wood, so that the under surface of the plate just touches the magnet. Fine iron-filings, produced by "draw-filing" Norway iron, which has been repeatedly annealed, are now sifted uniformly over the film of lac by means of a fine sieve. The spectrum is then produced on vibrating the plate, by letting fall vertically upon it, at different points, a light piece of copper wire. The plate is now cautiously lifted vertically off the magnet and placed on the end of a cylinder of pasteboard, which serves as a support in bringing it quite close to the under surface of a cast-iron plate (1 ft. diam. $\frac{1}{2}$ in. thick), which has been heated over a large Bunsen-flame. Thus the shellac is uniformly heated and the iron-filings, absorbing the radiation, sink into the softened film and are "fixed."

I generally allow the heat to act until the metallic lustre of the filings has disappeared, by sinking into the shellac, and the film appears quite transparent. This degree of action is necessary when photographic prints are to be made from the plate, but when they are to be used as lantern slides I do not carry the heating so far. After the plate has cooled, it is allowed to fall upon its ends, on a table, so that any filings which have not adhered may be removed.

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* The shellac dissolved in strong alcohol is allowed to stand a week or more, and the clear supernatant solution is then decanted.

A short experience will give the proper strength of shellac solution to obtain a film so thick as *just to be sufficient to hold the filings*, and the requisite amount of heat to firmly cement them, without injuring the transparency of the film.

The plates can now serve (1) for the most accurate measures upon the magnetic-field; (2) for a photographic positive, which, in the printing-frame will produce the lines in white upon a dark ground, giving most beautiful and distinct impressions;* (3) or, if it is required to exhibit these figures to an audience, the plates are provided with glass covers, kept from touching the spectra by intervening slips of card-board, and there result "slides," in every way fit for giving a fine exhibition, when the images are projected upon a screen. I have thus obtained images, clear and sharp, of over 12 feet in diameter.†

By this process many plates have been produced; showing the action of single magnets of various forms, and of juxtaposed bars; as well as the effects of electric currents led by wires through holes drilled in the plates. Those exhibiting the inductive action of magnets on bars of soft iron and the interaction of magnets and electric currents are peculiarly interesting. An approximate representation of the resultant lines of the terrestrial magnetic action has been obtained by magnetizing *equably tempered* steel discs of from 2 ins. to 3 ins., and even more, in diameter. The magnetic axis or axes of these discs are *predetermined* by making them the continuations of the axes of very powerful electro-magnets, terminated with cones of soft iron with slightly rounded apices. The arcs of the great circles, including the terrestrial magnetic poles, having been calculated, the axes of the electro-magnets are inclined to that angle, while the steel disc is held close to their poles. On passing the current the disc is magnetized and we have an approximate representation of a section of the earth's magnetic effect. These results when viewed as photographic prints, or, as exhibited by the lantern, are so beautiful and instructive as to appear to me to warrant this somewhat formal description of the process of their production.

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* Photographic prints from a series of eight of these plates I have presented to Harvard College; American Academy of Sciences; Sheffield Scientific School; Columbia College; Stevens Institute of Technology, Hoboken; Lehigh University, Pa.; American Philosophical Society; Franklin Institute; Peabody Institute, Balt.; Smithsonian Institution; Chicago Academy of Sciences; and to the University of Virginia—where they can be examined by the readers of this paper.

† Several of these are 16 ins. long by 10 wide.

December, 1870.

Since sending the above to press I have subjected plates, coated with "sensitized" collodion to the action of the magnetic field. I had hopes of thus obtaining a *physical* impress on the plate which would appear on flowing the "developer." Sensitized films on glass and on iron plates were placed over and between the poles of an electro-magnet with cores 1·7 in. in diameter. Some plates were developed after removal from the magnet, others while under the magnetic action,—with and without the light having acted upon them—but no trace of effect has been detected.

I had also imagined that the magnet's action should have placed the affinities in a more unstable condition, so that the film would rise in sensitiveness after exposure in the magnetic field; but this, also, I could not detect; nevertheless, I have not given up the supposition that some action will be evolved when more appropriate films, far higher magnetic action and more delicate measures of actinic effect are used.

February 13, 1871.

ART. XXXIX.—*Notice of a Fossil Forest in the Tertiary of California;* by Professor O. C. MARSH, of Yale College.

DURING the visit of the Yale College Scientific party to the Pacific Coast, in October last, several members of the expedition, including the writer, while on their way from San Francisco to the "Geysers," took occasion to examine a locality, a few miles from the route, where a number of fossil trunks of trees had recently been discovered. This point proved to be of much scientific interest, and, since it has received as yet apparently little or no attention from geologists, it may be well to note the more important results of our investigation.

The locality is situated on a high rocky ridge, in Napa county, California, about five miles southwest of Calistoga Hot Springs, and perhaps ten miles south of the summit of Mount St. Helena. The existence at this place of several petrified trunks of trees was first made public by Charles H. Denison, Esq., of San Francisco, who visited the spot in July last, and, soon after, gave a short account of the discovery in the San Francisco Bulletin. Our party was especially indebted to Mr. Denison for information on the subject, and for accompanying us to the locality during our first visit. The ridge on which the fossil trees were found belongs to the Coast Range series, and forms the divide between the Napa and Santa Rosa valleys.

It is about 2000 feet in height, and is mainly composed of metamorphic rocks of Cretaceous age,* which are in places, as we ascertained, overlaid, unconformably, by later Tertiary strata, consisting of light-colored, coarse sandstones, and beds of stratified volcanic ashes. This ridge had long been covered with a dense growth of "chaparral," but just before our visit a destructive fire had swept over a portion of it, rendering it comparatively easy to examine a large tract of country which apparently had never been explored.

A careful examination of the locality where the first prostrate trunks had been discovered soon made it evident that those now on the surface had all been weathered out of the volcanic tufa and sandstones, which form the summit of this part of the mountain ridge. Several large silicified trees were, indeed, subsequently found in the vicinity, projecting from the side of a steep bluff, which had partially escaped denudation. Extending our explorations among the mountains for several miles around, we were rewarded by the discovery of many additional fossil trunks at various points, showing conclusively that this Tertiary deposit contained the remains of an extensive forest of very large trees, which had apparently been overthrown and entombed by some volcanic irruption. Portions of nearly one hundred distinct trees, scattered over a tract three or four miles in extent, were found by our party, and the information we received from hunters and others, familiar with the surrounding country, renders it more than probable that the same beds, containing similar masses of silicified wood, extend over a much greater area.

The fossil trees washing out of this volcanic tufa were mostly of great size, and appeared to be closely related to some of the modern forest trees of the Pacific coast, especially the gigantic Conifers. One of the prostrate trunks examined during our explorations was only partially exposed above the surface, dipping with the strata about 10° to the northward. Its accessible portion, evidently but a small part of the original tree, measured sixty-three feet in length, and, although denuded of its bark and very much weathered, was over seven feet in diameter near its smaller end. On a high summit about a quarter of a mile west of this point, two other large trunks were found, one about five feet in diameter, lying east and west, with thirty feet of its length above the surface. The other rested directly on this, dipping with the strata to the north. The exposed fragments of this trunk indicated that the tree when standing could not have been less than twelve feet in diameter. These two trees had apparently fallen not far from where they were imbedded, as the bark was well preserved, both on the main trunks and on the small branches, numerous fragments of which were lying near. Many other trees were found, nearly or quite equal to these in size; and all those examined indicated a very large general growth for the original forest.

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* Geology of California, vol. i, p. 85.

All the trees discovered were prostrate, and most of them, after their petrifaction, had been broken transversely into several sections, apparently by the disturbance of the enclosing strata. A majority of the trunks had a general north and south direction, probably due to the course of the current that covered them with volcanic material, or perhaps indicating in some cases the position in which they had fallen. Several of the trunks had portions of their roots still attached, and some were evidently much decayed internally and worm eaten before their entombment. All the fossil wood observed was silicified, probably by means of hot alkaline waters containing silica in solution, a natural result of volcanic action, especially when occurring in connection with water, as was evidently the case in the present instance.

The trees closely examined appeared to be all conifers, and in their external characters, especially in the bark, mode of branching, and general habit of growth, most nearly resemble the modern redwoods, still flourishing in the same region. Dr. M. C. White, of New Haven, an authority in such matters, has, moreover, kindly made a microscopical examination of some of the best preserved specimens collected at this locality by the writer, and finds no essential difference between the structure of the fossil wood, and that of existing conifers of the genus *Sequoia*, to which the redwoods belong.

The beds enclosing the silicified wood appear to contain no other fossils, excepting here and there small fragments of charcoal, and hence their exact age is somewhat doubtful. As they rest unconformably on distorted and metamorphic Cretaceous strata, they are apparently as recent as Tertiary, and will probably prove to be Pliocene. The origin of the volcanic material which covered the forest cannot, perhaps, be definitely ascertained, without a careful examination of the surrounding region. It is not improbable, however, that it came from Mount St. Helena, the nearest volcanic peak, across the now intervening depression. Our party discovered on the western side of the Napa valley, along the base of the ridge, patches of a deposit of stratified tufa and gravel, which was evidently indentical with that containing the fossil trees on the summit. This would seem to imply that the upper portion of the valley had once been filled with these peculiar beds, and, through their denudation, had gradually attained its present proportions. However that may be, the volcanic deposit and its contents is certainly of great interest, even in this land of geological wonders, and is well worthy of a more systematic exploration than we were able to give it in the limited time at our command.

Yale College, New Haven, February 10th, 1871.

ART. XL.—*On the Determination of the Alkalies in Silicates by ignition with Carbonate of Lime and Sal-ammoniac;* by J. LAWRENCE SMITH, of Louisville, Ky.

IN the following description of a method of separating and determining the alkalies, I aim to give the minutest details. Numerous analyses have given me the experience here presented; and I am convinced that analytical chemists, if they follow out the directions, will not resort to any other known method. If there be a better method it is yet to be discovered. The presence of boracic, hydrofluoric and phosphoric acids in the minerals in no way interferes with the process. Even in silicates *soluble in acids*, I prefer this method, in common with other analysts, for its ease and accuracy. I made the researches during the latter part of 1852, and the details were published early in 1853.* Since then I have employed the process many hundreds of times, with the most accurate results. Some minor points were not completed satisfactorily until several years after the first notice of the method; these have since been perfected, and I now know of nothing further that is needed.

The purpose of this article is to give all the improvements, with a minute detail of the manipulations, and of the precautions necessary, all of which are simple and easily executed. In the two articles on the subject of alkali determination in minerals published in 1853, the whole subject was reviewed, and it is needless to return to it now. I then considered the processes by caustic baryta and its salts, and by hydrofluoric acid, and also detailed some experiments on the separation of the different alkalies from each other, and on the microscopic examination of the same, etc. It was proved that, after the caustic alkalies, the most powerful agent to attack silicates at a high temperature is caustic lime, a fact not new to chemists. But for the purpose of arriving conveniently by this method at *a quantitative determination of the alkalies in silicates*, certain methods of manipulation, and facts with regard to quantity of material, admixture, etc. had to be discovered; and in them resides the success of my process—converting the most difficult parts of the analysis of a silicate into the easiest.

The methods of analysis by caustic baryta and by means of its carbonate, are now no longer used, for various reasons fully detailed by Rose in his Analytical Chemistry. The method still extensively employed is that with hydrofluoric acid, proposed by Berzelius; and when used with the necessary precautions, it has seemed to decompose all silicates; still, according to Rose, there are siliceóus compounds that cannot be completely decomposed by hydrofluoric acid.*

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* Shortly after my first publication in this country, M. St. Claire Deville made known his method of analyzing the silicates by fusion with carbonate of lime, but the nature of his process and the objects to be arrived at were quite different from those attained in this process.

Dismissing all criticism, I at once proceed to the method which is the subject of this article, viz: the *Decomposition of Silicates by ignition with Carbonate of Lime and Sal-ammoniac.* A mixture of carbonate of lime and sal-ammoniac is used in the decomposition simply for the purpose of bringing the caustic lime to act, in a most thorough manner, upon the silicates at red heat.†

Pure carbonate of lime.—The first requisite is pure carbonate of lime. This is made in my laboratory, as follows: Take as good marble (calcite) as can be conveniently found, and dissolve it in hydrochloric acid (it is not necessary that the acid be perfectly pure), add an excess of the marble and warm the solution; to it add lime water or some milk of lime made from pure lime, until the solution is alkaline to test-paper; the lime is added to precipitate any magnesia, phosphate of lime, &c., that may have existed in the marble. Filter this solution and precipitate with carbonate of ammonia, after heating to at least 160° F.‡ The carbonate of lime thus precipitated is to be thrown on a filter and well washed with distilled water. Thus prepared, the carbonate of lime is a dense powder and perfectly pure, or if it contain any impurity, it will be a trace of carbonate of baryta or strontia, which in no way interferes with its use.

Sal-ammoniac.—To obtain this reagent in the most convenient form, take some fragments of clean sublimed sal-ammoniac, dissolve them in water with a gentle heat, filter, evaporate the filtrate over a steam bath or a sand bath, or by means of any other convenient gentle heat, and as the crystals deposit themselves, stir the solution to keep them small; when half or two-thirds of the sal-ammoniac is deposited, pour off the liquid without waiting for it to cool, throw on a cotton filter, and dry the crystals at the temperature of the atmosphere. In this way, sal-ammoniac is obtained that can be easily pulverized.

Vessel for the decomposition.—The ordinary platinum crucible can be used for this purpose, and for many years was employed by me. It was found, however, that while it is the best, hitherto contrived, both for precision and ease, there was yet a very minute quantity of alkalies lost by volatilization; and I made further researches to overcome this small loss. This I have successfully accomplished, and for some time I have used an improved form of crucible. The one for half to one gram of silicate, is of the following form and dimensions, viz: an elongated, slightly conical crucible with rounded bottom and cover (either with or without the central wire by which to hold it); length 95 mm.; diameter of opening 22 mm.; diameter of smaller end just at the turn of the bottom 16 mm.; weight about 35 to 40 grams. These are now made by Messrs. Johnson, Mattley & Co., Hatton Garden, London, to whom I have furnished all the necessary directions. This shape is given it in order that the portion of the crucible containing the mixture may be heated strongly, while the upper portion is below a red heat.

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* The process used by Deville, in fusing with carbonate of lime, is in most cases better than that by hydrofluoric acid, and one that I should use in preference to all others except the one now under notice.

† Chloride of calcium at a red heat will dissolve more or less caustic lime.

‡ This precaution must not be overlooked, as it is desirable to obtain the precipitated carbonate of lime as dense as possible. If the carbonate of ammonia be added to the cold solution, the precipitate, at first gelatinous, will ultimately become much more dense and settle readily; the same is true if the mixture be heated after the addition of the carbonate; but in neither case will it be as dense as when the carbonate is added to the hot solution of chlorid of calcium. The reaction in the analysis is in no way affected by the form of the carbonate of lime; but by using the denser form, the mixture occupies less space in the crucible.

Manner of heating the crucible.—The ordinary crucible, if used, may be heated in the manner commonly employed for the fusion of silicates. If the new form of crucible, however, is employed, then the upper part is grasped by a convenient metallic clamp in a slightly inclined position, and a moderate blast from the table blow-pipe made to play upon it for about 25 or 30 minutes. But as gas is to be found in every well-mounted laboratory, Bunsen burners of all dimensions are used, and when properly applied, can be made to give all gradations of heat; a simple, cheap, and convenient furnace, with a properly arranged draught, can be made to accomplish all fusions of silicates without the aid of any manual labor, and I therefore employ such an apparatus. (A description of it is given at the close of this article.)

Method of analysis.—We have now the pure carbonate of lime, granular sal-ammoniac and the proper crucible. The silicate should be well pulverized in an agate mortar;* and half a gram or one gram of it is taken. The former amount is most commonly used, it being sufficient and best manipulated in the crucible; a gram, however, may be conveniently employed. The weighed mineral is placed in a large agate mortar, or better in a glazed porcelain mortar, of half to one pint capacity; an equal quantity of the granular sal-ammoniac is weighed out (a centigram, more or less, is of no consequence), and put into the mortar with the mineral, and the two are rubbed together intimately. After this, add eight parts of the carbonate of lime in three or four portions, and mix intimately after each addition; empty the contents of the mortar completely upon a piece of glazed paper, that ought always to be under the mortar, and introduce into the crucible. The crucible is now tapped gently upon the table and the contents settled down.

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* While in all mineral analysis thorough pulverization of the mineral is usually essential, still it is a singular fact, very good analyses can be made with this method even when the powder is tolerably coarse, and in some experiments with lepidolite, I used powder of which much of it was in particles of from 1-40 to 1-30 of an inch, and obtained excellent results. Notwithstanding this, thorough trituration of the mineral is recommended.

The crucible is then clasped by a metallic clamp in an inclined position, or it is placed in the upper part of the support referred to in the latter part of this article, leaving outside about three-fourths of an inch or one inch. By means of a small Bunsen burner the heat is brought to bear just above the top of the mixture and gradually carried toward the lower part, until the sal-ammoniac is completely decomposed, which takes about five minutes; heat is then applied in the manner suggested, either with the blast, or with the burner referred to, acting by its own draught, and the whole kept up to bright red heat, for from 40 to 60 minutes. It is well to avoid too intense a heat.

The crucible is now allowed to cool, when the contents will be found to be more or less agglomerated in the form of a semi-fused mass. A glass rod or blunt steel point will most commonly detach the mass, which is then dropped into a platinum or porcelain capsule of about 150 centimeters capacity and 60 or 80 centimeters, and distilled water added. After some time, the mass will slack and crumble in the manner of lime; still better, this may be hastened by bringing the contents of the capsule to the boiling point, either over a lamp or water-bath; at the same time, water is put into the crucible to slack out any small particles that may adhere to it, and subsequently this is added to that in the capsule, *washing off the cover of the crucible also.*

After the mass is completely slacked, the analysis may be proceeded with; as a general thing, I prefer to allow the digestion to continue six or eight hours, though this is not necessary.

If the contents of the crucible are not easily detached, do not use very much force as the crucible may be injured by it, but fill the crucible to about two-thirds its capacity with water, bring it almost to the boiling point, and lay it in the capsule with the upper portion resting on the edge, the lime will slack in the crucible, and then may be washed thoroughly into the dish; also, as before, the cover is to be washed off.

We have now by this treatment with water, the excess of lime slacked into a hydrate, and some of the lime combined with the silica and other ingredients of the silicate in an impalpable form. In solution, there is an excess of chloride of calcium formed in the operation, and all the alkalies originally contained in the mineral, as chlorides. All that now remains to be done is to filter and separate the lime as carbonate and nothing is left but the chlorides of the alkalies. To do this, proceed as follows: Throw the contents of the capsule on a filter, the best size of which for the quantity above specified, is one 3 to 3½ inches in diameter; wash well, to do which requires about 200 centimeters of water; the washing is executed rapidly. The contents of the filter (except in those cases where the amount of the mineral is very small and there is no more for the estimation of the other constituents) is of no use, unless it be desired to heat again to see if any alkali still remains in it.

The filtrate contains in solution all the alkalies of the mineral, together with some chloride of calcium and caustic lime; to this solution, after it has been thrown into a platinum or porcelain capsule, is added a solution of pure carbonate of ammonia (an amount equal to about one and a half grams is required). This precipitates all the lime as carbonate; it is not, however, filtered immediately, but is evaporated over a water-bath to about 40 centimeters, and to this is added again a little carbonate of ammonia, and a few drops of caustic ammonia, to precipitate the little lime that is redissolved by the action of the sal-ammoniac on the carbonate of lime; filter on a small filter (2 in.) which is readily and thoroughly washed with but little water, and the filtrate allowed to run into a small beaker. In this filtrate are all the alkalies as chlorides, and a little sal-ammoniac. Add a drop of carbonate of ammonia, to make sure that no lime is present. Evaporate over a water-bath in a tared platinum dish, in which the alkalies are to be weighed; the capsule used is about 60 centimeters capacity, and during the evaporation is never filled to more than two-thirds its capacity.

After the filtrate has been evaporated to dryness, the bottom of the dish is dried, and on a proper support heated very gently by a Bunsen flame, to drive off the little sal-ammoniac. It is well to cover the capsule with a piece of thin platinum to prevent any possible loss by the spirting of the salt; after the sal-ammoniac has been driven off by gradually increasing the heat, the temperature of the dish is brought up to a point a little below redness, the cover being off. (The cover can be cleaned from any sal-ammoniac that may have condensed upon it by heating it over the lamp.) The capsule is again covered, and when sufficiently cooled, and before becoming fully cold, is placed on the balance and weighed. This weight gives as chlorides, the amount of alkalies contained in the mineral.

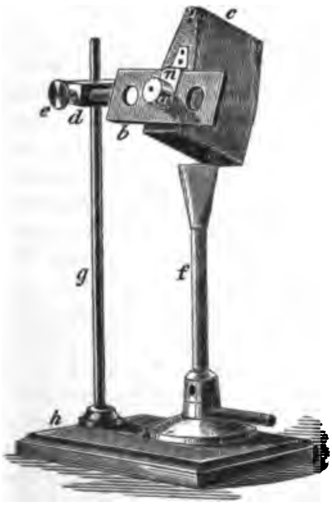
If the chloride of lithia be present, it is necessary to weigh rapidly, for this salt being very deliquescent takes moisture rapidly.

It not unfrequently happens that the chlorides at the end of the analysis are more or less colored with a small amount of carbon arising from certain constituents in carbonate of ammonia; the quantity is usually very minute and in no way affects the accuracy of the analysis. In selecting pure carbonate of ammonia for analytical purposes, it is well to take specimens that are not colored by the action of light.

It only remains now to separate the alkalies by the known methods. Under this head I have made several observations, that at some future time may be published as soon as the results are sufficiently definite.

A special arrangement for heating the crucible by gas.—The support and burner, where gas is to be had, are simple in their character and have been contrived after a great variety of experiments with gas furnaces. The figure here given illustrates the stand, burner, crucible, &c., and is about one-sixth the natural size.[*]

h is the stand with its rod *g*; *d* is a brass clamp with two holes at right angle to each other having two binding screws; it slides on the rod *g*; the second hole is for a round arm attached to *b*, the binding screw *e* fixing it in any position. *b* is a plate of cast iron five to six mm. thick, ten to eleven cm. long, and four and one half cm. broad, having a hole in its center large enough to admit the crucible to within about 15 mm. of the cover, without binding. *a* is the crucible already referred to which is made to incline a few degrees downward by turning the plate of iron that supports it. *c* is a chimney of sheet iron, eight to nine cm. long, ten cm. high, the width at the bottom being about 4 cm. at one end, and about three cm. at the other end. It is made with the sides straight for about four cm., then inclines toward the top so as to leave the width of the opening at the top about one cm. A piece is cut out of the front of the chimney of the width of the diameter of the hole in the iron support, and about four cm. in length, being semi-circular at the top, fitting over the platinum crucible. Just above this part of the chimney is riveted a piece of sheet iron in the form of a flattened hook *n* which holds the chimney in place by being slipped over the top of the crucible support; it serves as a protection to the crucible against the cooling of the currents of air.



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[*] This apparatus can be obtained from T. E. Jenkins & Co., of Louisville, Ky., importers and dealers in chemical apparatus.

f is the burner which has been described in an article on flame-heat in this Journal, II, vol. 1, p. 341. The upper opening of it is a slit from 1½ to 2 mm. in width, and from 3½ to 4½ cm. long, and when used is brought within about two cm. of the lowest point of the crucible, the end of the flame just playing around the lower end of the crucible; the gas enters the lower part of the burner by two small holes of one-sixteenth of an inch, furnishing at one inch pressure about 5½ cubic feet of gas per hour; the precaution must be observed already referred to, in heating the crucible at first gently above the mixture. It is surprising to see the effect produced by this simple burner as here used; 8 grams of precipitated carbonate of lime can be decomposed to within two or three per cent in one hour, and when mixed with silica or a silicate, in a very much shorter space of time; although in my analysis I employ one hour as it requires no attention after the operation is once started. This form of furnace and crucible is found to be convenient for other operations.

Although the details here given are long, the time occupied in the analysis is short, and the necessary precautions are of a simple character, so much so, that results obtained by students in beginning chemical analysis have been found by me far more reliable and less variable on the alkalies of the silicates than on any of the other constituents. Good alkali determinations can be made in three hours or less from the commencement of the operation, hastening the evaporation by more direct application of the heat, which of course requires more close watching

It is a common practice of mine, when a silicate presents itself of which there are no physical means of ascertaining its nature, to make at once an alkali determination, which not unfrequently indicates immediately what it is if it be a known silicate containing an alkali; and if an unknown compound, the analysis made is one step in the examination.

ART. XLI.—*On the Great Sun-spot of June*, 1843; by Professor DANIEL KIRKWOOD, Bloomington, Indiana.

ONE of the largest and most remarkable spots ever seen on the sun's disc appeared in June, 1843, and continued visible to the naked eye for 7 or 8 days. The diameter of this spot was, according to Schwabe, 74,000 miles; so that its area was many times greater than that of the earth's surface. Now, it has been observed during a number of sun-spot cycles that the larger spots are generally found at or near the epoch of the greatest numbers. The year 1843 was, however, a *minimum* epoch of the eleven-year cycle. It would seem, therefore, that the formation of this extraordinary spot was an anomaly, and that its origin ought not to be looked for in the *general cause* of the spots of Schwabe's cycle.

As having a possible bearing on the question under consideration let us refer to a phenomenon observed at the same moment, on the first of September, 1859, by Mr. Carrington, at Redhill, and Mr. Hodgson, at Highgate. "Mr. Carrington had directed his telescope to the sun, and was engaged in observing his spots, when suddenly two intensely luminous bodies burst into view, on its surface. They moved side by side through a space of about thirty-five thousand miles, first increasing in brightness, then fading away. In five minutes they had vanished. * * * It is a remarkable circumstance, that the observations at Kew show that on the very day, and at the very hour and minute of this unexpected and curious phenomenon, a moderate but marked magnetic disturbance took place; and a storm, or great disturbance of the magnetic element, occurred four hours after midnight, extending to the southern hemisphere."

The opinion has been expressed by more than one astronomer that this phenomenon was produced by the fall of meteoric matter upon the sun's surface. Now, the fact may be worthy of note that the comet of 1843, which had the least perihelion distance of any on record, actually grazed the solar atmosphere about three months before the appearance of the great sun-spot of the same year. The comet's least distance from the sun was about 65,000 miles. Had it approached but little nearer, the resistance of the atmosphere would probably have brought its entire mass to the solar surface. Even at its actual distance it must have produced considerable atmospheric disturbance. But the recent discovery that a number of comets are associated with meteoric matter, traveling in nearly the same orbits, suggests the inquiry whether an enormous meteorite following in the comet's train, and having a somewhat less perihelion distance, may not have been precipitated upon the sun, thus producing the great disturbance observed so shortly after the comet's perihelion passage.

ART. XLII.—*Calorimetric Investigations*; by R. BUNSEN.*

(Continued from page 179.)

The Ice Calorimeter.

IN order first to become better acquainted with the phenomena attending the formation of ice, although only in so far as they come under consideration in using the instrument, the calorimeter, containing a cylinder of ice and carefully surrounded with snow, was kept long under observation. It stood, as in all the following experiments, in a large earthenware decanting jar, through whose lower orifice the water dropping from the melted snow could continually flow off, so that a contact between the lower part of the instrument and the water thus formed was not to be feared. The instrument soon surrounds itself with a coherent mass of semisolid snow (firneis). If, after twelve or fifteen hours, a considerable cavity has been formed on the walls of the jar by the external melting of this mass, this cavity is then increased by smoothing off the loosely coherent substance with a spatula-shaped stick, the portions thus scraped off being stuffed into the vacent spaces under the calorimeter, and the snow lost by melting replaced with fresh. The first experiments were made with freshly fallen snow, which had been collected from a clean substratum of the same substance, and carefully shielded from every contamination arising from the soil. Of this snow, one hundred weight was preserved in a clean wooden chest, as a stock for the refillings during the experiments. With such a stock the calorimeter may by filling up twice daily, be kept for weeks in continual use without the necessity of renewing the ice-cylinder.

Throughout the entire duration of the observations, which occupied five days, the inner vessel enclosed in the ice-cylinder was kept closed with a rubber stopper, and the whole instrument, with the exception of the scale, surrounded on all sides with melting snow. The temperature of the room in which the observations were made varied between 0°·5 C. and 6°·C. The observations are presented in the following table 1. Column I, contains the time of the observations in hours. Column II gives the readings of the calorimeter scale for these times; the observed values are characterized by a star, the others have been calculated from these by interpolation. Up to the thirty-first hour the mercury which left the graduated tube was weighed; and the weight thus found transformed into scale-divisions according to equation (1). Column III has been calculated with the aid of equation (3), and gives the weight of the ice, expressed in grams, which has been formed in the instrument from the beginning of the period in question.

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* Translated for this Journal, with permission of the author, from Poggendorff's Annalen der Physik und Chemie, Bd. cxli, by Dr. G. E. MOORE, of San Francisco.

TABLE I.

I.	II.	III.	I.	II.	III.	I.	II.	III.
0	0·0	0·0	41	2739·8	2·3358	82	2810·5	2·3961
1	633·8	0·5404	42	2740·3	2·3363	83	2811·6	2·3971
2	1267·6	1·0807	43	2740·8	2·3367	84	2812·8	2·3981
3	1901·4 *	1·6211	44	2741·3	2·3371	85	2813·9	2·3990
4	2033·1	1·7334	45	2741·8 *	2·3376	86	2815·0	2·4000
5	2164·8	1·8456	46	2743·3 *	2·3389	87	2816·1	2·4009
6	2296·5	1·9579	47	2744·7	2·3401	88	2817·2	2·4018
7	2428·2 *	2·0702	48	2746·2 *	2·3413	89	2818·4	2·4029
8	2443·4	2·0832	49	2747·0	2·3420	90	2819·5	2·4038
9	2458·6	2·0961	50	2747·8	2·3427	91	2820·6 *	2·4048
10	2473·8	2·1091	51	2748·6	2·3434	92	2822·2	2·4061
11	2489·0	2·1220	52	2749·4	2·3441	93	2823·9 *	2·4076
12	2504·2 *	2·1350	53	2750·3 *	2·3448	94	2825·1	2·4086
13	2528·6	2·1558	54	2751·6 *	2·3460	95	2826·4	2·4097
14	2553·0	2·1766	55	2753·0 *	2·3471	96	2827·6 *	2·4107
15	2577·4	2·1974	56	2754·4	2·3483	97	2828·9	2·4118
16	2601·8	2·2182	57	2755·8 *	2·3495	98	2830·2	2·4130
17	2626·2	2·2390	58	2758·0	2·3514	99	2831·6	2·4141
18	2650·6	2·2598	59	2760·2	2·3583	100	2832·9 *	2·4152
19	2675·0	2·2806	60	2762·4	2·3551	101	2834·2	2·4164
20	2699·4	2·3014	61	2764·6	2·3570	102	2835·6	2·4176
21	2723·8 *	2·3222	62	2766·9	2·3590	103	2836·9 *	2·4186
22	2724·8	2·3231	63	2769·1	2·3608	104	2837·6	2·4193
23	2725·8	2·3239	64	2771·3	2·3627	105	2838·3	2·4199
24	2726·8	2·3248	65	2773·5	2·3591	106	2839·0	2·4204
25	2727·8	2·3256	66	2775·7	2·3665	107	2839·7	2·4211
26	2728·8	2·3265	67	2777·9	2·3684	108	2840·4	2·4217
27	2729·8	2·3273	68	2780·9	2·3709	109	2841·1	2·4223
28	2730·8	2·3282	69	2783·9 *	2·3735	110	2841·8	2·4229
29	2731·8	2·3291	70	2786·2	2·3754	111	2842·5	2·4234
30	2732·8	2·3297	71	2788·5 *	2·3774	112	2843·2 *	2·4240
31	2733·8	2·3307	72	2790·7	2·3793	113	2843·9	2·4246
32	2734·8	2·3316	73	2792·9	2·3811	114	2844·6 *	2·4252
33	2735·8 *	2·3324	74	2795·0	2·3829	115	2844·6	2·4252
34	2736·3	2·3329	75	2797·1	2·3847	116	2844·6 *	2·4252
35	2736·8	2·3333	76	2799·2	2·3865	117	2844·6	2·4252
36	2737·3	2·3337	77	2801·3 *	2·3883	118	2844·6 *	2·4252
37	2737·7	2·3342	78	2803·2	2·3899	119	2844·6	2·4252
38	2738·3	2·3346	79	2805·2 *	2·3916	120	2844·6 *	2·4252
39	2738·8	2·3350	80	2807·3	2·3934			
40	2739·3	2·3354	81	2809·4 *	2·3952			

The table shows that about two grams of the water, contained in the calorimeter, froze at the temperature of melting snow during the first seven hours, that this freezing at the temperature of melting snow continued 114 hours in diminishing ratio, and that after this long time a period began, in which the water did not freeze further at the temperature of melting snow. The disproportionately great formation of ice at the beginning of the experiment arose evidently from the low temperature which the cylinder of ice, formed at –15° C. to –20° C., originally possessed, as the following consideration shows. Let it be assumed that the amount of ice g, formed during the first seven hours originated in the loss of heat which the water suffered in order to warm the ice-cylinder from $-t^\circ$ to 0° C., then will the mean temperature, which the ice-cylinder must have had in order to produce the above named weight of ice, result from the equation $t = -\frac{lq}{s_w G}$, wherein l signifies the heat of melting for water, s_w the specific heat of ice, and G the weight of the ice-cylinder cooled to t°. In this equation only G is unknown. After the termination of the series of experiments in table 1, in order to determine G, the open end of the scale tube was dipped into a weighed glass vessel full of mercury, and, after the ice cylinder had melted and the instrument had been brought again to 0° C., the loss in weight G_1 of the mercury vessel was ascertained. The desired weight of the ice-cylinder is $G = \frac{G_1 p}{s_q v}$, wherein s_q signifies the specific gravity of mercury as 0° C., p the weight of melted ice corresponding to one division on the scale (equation 3), v the volume of one scale division (equation 1). The values of the terms occurring in this and the preceding equation are:

$l = 80{\cdot}03$ $s_q = 13{\cdot}596$ $s_w = 0{\cdot}48$
$q = 2{\cdot}13$ grm. $G_1 = 61{\cdot}227$ grm. $p = 0{\cdot}0008526$ grm.
$v = 0{\cdot}00007733$ cubic centimeter.

By the substitution of these values in the equation there results, as the weight of the ice cylinder used in the observations $G = 49{\cdot}65$ grm.
and for its temperature $t = -6^\circ{\cdot}95$ C.

The ice cylinder, which had been produced at a temperature of at least −15° C., needed therefore to have possessed, at the time the instrument was placed in the snow, a temperatue -7° C. only, in order to have produced by its warming to 0° C. the formation of ice observed during the first seven hours. As from the determination of specific heat communicated beyond, it may be concluded that a period of seven hours is far more than sufficient to equalize a difference of temperature of 7° C. in the instrument, it is necessary to ascribe the ice formation which is visible in the table and which lasted more than 100 hours, to another cause than the one under consideration. Without entering further into the question whether this cause is to be sought for in the air contained in the snow water, as C. Schultz* assumes, or whether the passage of the snow to the semi-solid state (firneis), plays therein a part, it may suffice in the first place, to give prominence only to those influences determining a lowering of the melting point of ice, which are particularly deserving of attention in the employment of the ice-calorimeter. If the pure snow which surrounds the instrument be saturated with as much boiled-out or distilled water of 0° C., previously shaken with air, as it can retain after the excess has been allowed to drain off, there ensues, at least during the first twelve hours, during which alone the observations were carried on, no freezing but such a melting of the ice in the interior of the instrument that it would, under these circumstances, be entirely unserviceable for observation. On the other hand the slightest impurity of the snow determines such a large continual deposition of ice on the ice cylinder, that the mercury thread often advances in one minute several divisions on the scale. Snow which has absorbed even traces of salts from the soil, or of animal, or vegetable impurities from the street pavement, shows this lowering of the melting point in the most striking manner. River ice of such purity that the water obtained from it by melting, showed with barium chloride and silver solution only after a long time, a scarcely perceptible turbidness produced in the instrument during three days two grams of ice. After these observations it is self-apparent that only the purest snow can be used in the experiments. It is also advantageous to work in an apartment whose temperature is not too high above 0° C., and not to begin the observations, until the formation of ice on the ice-cylinder does not exceed a few scale divisions in the hour. Above all, however, care must be taken that, before the instrument is allowed to take, in the snow, a constant temperature, a small layer of water has been formed by melting between the glass walls and the adjacent ice-cylinder, in order that unequal tension and its consequent elastic after-effect may be avoided.

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* Pogg. Annalen, cxxxvii, 253.

The accuracy of the observations depends, however, most essentially upon the care which has been taken in the original arrangement of the instrument, that all the air absorbed by the mercury and water be removed. This is to be attained in the following manner: the instrument, filled to the half with boiled out water, is fastened with the mouth turned downward on the arm of a retort-holder, the mouth of the tube *c*, fig. 1, which is not yet provided with an iron casing, is sunk in water which is kept in constant ebullition in a beaker-glass, and the water in the instrument which reaches to β kept boiling until it has evaporated to $\frac{1}{3}$. If now the lamp used to heat the apparatus be removed, the latter will fill itself with airless water. It is allowed to cool and is then, after it has been placed upright as in the drawing, filled to the height β with so much freshly boiled-out mercury, that the mercury level in the vessel *b* stands about equally high with that in the tube *c*. The water is now for the most part removed with a pipette from the tube *c*, the tube is freed from all moisture by means of a current of dry air produced by the water air-pump, and only then is the iron head-piece *d* cemented on with the finest sealing wax, in such a manner, that the tube *c* projects inside to some distance above the bottom, in order that later, the stopper bearing the scale may rest in the mouth of the glass tube *c* and not in the iron casing. The last filling with boiled mercury to the level γ is performed by the aid of a capillary glass tube, in order to avoid all air bubbles on the sides of the tube.

In order to place the mercury thread in each experiment on one of the first divisions of the scale, it suffices to press the cork of the graduated tube, with a rotary movement, somewhat deeper into the mercury tube *c*, fig. 1. If the thread has thereby exceeded the commencement of the scale, there is a small brass weight, fastened on a thread and previously warmed by contact with the hand or tongue, sunk into the fluid *a*, fig. 1. If the weight of the brass weight be g grams, its temperature t, its specific heat s_m, the latent heat of melting for water l, and the weight of melted ice, obtained by equation (2), which corresponds to an oscillation of one scale division, denoted by p, then the oscillation produced by the brass weight g is equal to $\frac{s_m t g}{l p}$ scale divisions. If we let

$t = 37°$ C. $s_m = 0{\cdot}0939$ $l = 80{\cdot}03$ $p = 0{\cdot}000853$

and g equal successively 0·1, 0·2, 0·4, 0·6, ... grams, the following retreats of the mercury thread, expressed in round numbers, will be obtained.

0·1 grm.	5 scale divisions.	0·6 grm.	30 scale divisions.
0·2 "	10 " "	0·8 "	40 " "
0·4 "	20 " "	1·0 "	50 " "

By dipping in one of these brass weights, previously warmed under the tongue, the mercury thread can be made to retreat to the desired extent. The oscillations corresponding to the little weights, which were only warmed to 37° C., are well adapted to give an idea of the extraordinary delicacy of the instrument. The increase of temperature which 0·4 grams of brass at 37° C. would produce by immersion in the mass of water in the instrument, amounting to about 20 grams would displace the mercury thread of a centigrade thermometer only $0°{\cdot}07$, that of the just described calorimeter, however, twenty scale divisions, each of which was, in the instrument employed, one millimeter in length.

In relation to the readings on the scale, it is still to be observed that, before such observation of the scale tube, which is best to be made with the telescope, the former must, particularly when it is very narrow, be gently agitated by repeated rapping until the capillary resistance is overcome, and the mercury thread does not retreat by further rapping.

Table 1 shows already that the mercury thread of the instrument is generally not perfectly stationary. The displacement, which, in a positive as in a negative sense may amount to 1 to 3 divisions in the hour, is, as the observer may easily perceive by the employment of the calorimeter, nearly proportional to the time. The slight error thus introduced may be eliminated in the following manner: As soon as it is seen that the instrument has become sufficiently stationary, the height of the mercury thread is noted from 30 to 30 minutes. If the displacement of the latter amounts in m minutes to r_0 scale divisions, then the displacement to be ascribed to foreign influences is for one minute $\frac{r_0}{m_0}$.

The hour M_0 and the height of the mercury thread Q_0 are now observed at the moment, when the substance to be investigated is allowed to fall from the heating vessel *f*, fig. 4, (see page 173) into the calorimeter vessel *a*, fig. 1, and both observations are repeated one hour later, whereby further M_1 and Q result; finally the movement of the mercury thread independent of the heat to be measured, is once more determined, as in the beginning of the experiment $\frac{r_1}{m_1}$.

The mean displacement of the mercury thread, independen of the experiment, amounts therefore in one minute to

$$\frac{1}{2}\left(\frac{r_0}{m_0}+\frac{r_1}{m_1}\right)$$

and throughout the entire duration of the experiment to

$$(M_1-M_0)\frac{1}{2}\left(\frac{r_0}{m_0}+\frac{r_1}{m_1}\right)$$

scale divisions. This value is to be added to the oscillation the mercury thread Q_0-Q_1 observed during the experiment a correction, and especially, with the negative sign prefixe when the displacement independent of the experiment toc place in the way of ice melting, with the positive sign in th opposite case. For the oscillation T, corresponding to the qua tity of heat to be measured, the equation

$$T=(Q_0-Q_1)+(M_1-M_0)\frac{1}{2}\left(\frac{r_0}{m_0}+\frac{r_1}{m_1}\right)$$

is therefore obtained, wherein it is hardly necessary to men that, for the direct readings, their values according t table of calibrations are to be substituted.

(To be continued.)

T. XLIII.—*On the Solar Protuberances; Abstract of a Note read by* Prof. L. RESPIGHI, *before the Accademia de' Nuovi Lincei,* Dec. 4, 1870.* With a plate.

THIS note is founded upon spectroscopic observations of the border and protuberances of the sun regularly made by Prof. Respighi, at the Campidoglio observatory in Rome, from Oct., 1869, to Nov., 1870. The author deduces some important facts relative to the forms, size, development, and transformation of the protuberances; to their duration, and the manner of their distribution over the solar disk; and to their connection with the other solar phenomena, namely, the spots and the faculæ.

Among the surprisingly various and singular forms of the protuberances, he finds those that have the appearance of gaseous masses issuing from the sun's surface to be so marked and constant, that it is necessary to conclude that they are really produced by gaseous eruptions from within the body of the sun, taking place with more or less energy, and on a varying scale of grandeur.

Not being able to explain the various modes according to which the erupted masses are ramified and diffused, by referring them to the simple velocity of eruption combined with the action of gravitation, and with the natural expansion of the jets, or to the resistance of the solar atmosphere, or on the supposition of powerful currents in the latter, he finds it necessary to admit the concurrence of other forces acting within the erupted masses, and between these and the body of the sun.

In regard to the dimensions of the protuberances, spectroscopic observations show that they may vary between the most extreme limits, from jets which are very small and low, to those of enormous section and of immense altitude. Among the protuberances sketched by Prof. Respighi, which exceed 4,000, there are more than 700 not less than 1′ high, that is, more than three times the diameter of the earth in altitude, and among [illegible] not less than 6′, that is, more than 20 times the earth's diameter in height.

To the immense altitudes of the protuberances, correspond, often, expansions or ramifications in a horizontal direction, which are truly astounding, and in which the hydrogen dif[illegible] in vast volumes, or stretches out in branches more or less subtile and of enormous length.

Prof. Respighi observes that the loftiest protuberances observed by him show, besides the spectral line C, which is very distinct, also the line F, and the yellow line D^3,* to their very summits, a fact already remarked by him in a previous note.

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* Translated for this Journal, by Prof. ARTHUR W. WRIGHT, of Williams College, Williamstown, Mass., from Secchi's Bull. Met., Rome, Dec. 31, 1870.

The development of the protuberances is ordinarily announced by bright points or patches standing out upon the chromosphere (*strato rosato*), from which subsequently burst forth jets more or less subtile, which rise, sometimes slowly, sometimes rapidly, to considerable elevations, and then fall back in parabolic forms upon the sun, or diffuse themselves in masses of varying and sometimes very singular conformation, and subject to more or less rapid transformations. Prof. Respighi has been able now and then to be a witness of the development, in the neighborhood of the spots, of enormous protuberances, produced by the eruption of groups of very slender and brilliant jets, which in a short time spread into great cloudy masses, either settling down upon the surface of the sun, or gradually vanishing at a great height above it. An example of this kind of eruption is given in the plate, in the figure of the protuberance No. 14, observed October 29, 1870.

Respecting the duration of the spots, it is found that while some of them are developed in the space of a few minutes, and, after undergoing rapid transformations, in a few minutes thin out and disappear, others remain visible for a long time, sometimes retaining in their forms some characteristic traits. Those which are the most variable and evanescent, are produced in the neighborhood of the spots. Outside the zone of spots, up to about 70° in latitude, the protuberances commonly remain visible for many days, so that it is possible to follow by them the rotation of the sun; and it has been possible, in the course of the observations, to observe the passage of some of the protuberances from one border of the sun to the other, and also their return to the first border, after having made a complete revolution. The time of the sun's rotation as deduced by means of the protuberances agrees very closely with that obtained by observation of the spots near the equator; which shows that the retardation of this rotation observed in the spots distant from the equator, is an appearance due to the proper motion of the spots themselves.

In regard to the distribution of the protuberances upon the solar surface, Prof. Respighi finds the results deduced from the earlier observations confirmed, namely, that in the circumpolar regions, within a distance of 20° from the poles, the protuberances are either not found, or occur only exceptionally; though notwithstanding this, the surface of the sun in these regions cannot be in a condition of perfect calm; for the appearance of small jets, and the irregularity and variability of the chromosphere, show that even in those regions there is a state of continuous eruption, though on a very small scale.

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* This is doubtless the line observed by Mr. Lockyer, Oct. 20, 1868. In a communication to the Royal Society made that year, he says, speaking of the observation of a solar protuberance, "two of the lines correspond with Fraunhofer's C and F; another lies 8° or 9° (of Kirchhoff's scale) from D toward E. * * * It is remarked that the line near D has no corresponding line ordinarily visible in the solar spectrum. See also Mr. Lockyer's account of the recent eclipse (from *Nature*; this Journal, III, i, 229) where this line is attributed to a new element, a deduction first made we understand by Prof. Young. A. W. W.

Considering the whole body of observations made, it appears that the northern hemisphere is perceptibly more characterized by great protuberances and gigantic eruptions than the southern, and that in the former large protuberances are on rare occasions seen at distances less than 20° from the pole, a thing which never happens in the southern hemisphere. In the vicinity of the equator, protuberances of great size occur less frequently than in higher latitudes.

As to the connection of the protuberances with the faculæ, it is found that the latter are commonly accompanied by protuberances of considerable size, though without being confounded with them in the same phenomenon. Thus it would appear to be proved that the faculæ are special modifications of the photosphere in the neighborhood of powerful eruptions.

The following results have been deduced from a great number of observations made upon the border of the sun's disk, in the region of the spots :—

1. In the neighborhood of the spots the chromosphere (*strato rosato*) is rather low, quite regular and intensely bright.
2. Upon the exact locality of a spot, or rather over its nucleus, the chromosphere is generally very low and sometimes totally wanting.
3. At the nucleus, either there are no eruptions or they are confined to jets of great subtilty and little duration.
4. The nuclei of the spots are either totally obscure or possess very feeble luminosity.
5. Along the borders of the spots, jets are thrown up of extraordinary intensity and violence and of very definite configuration.
6. The jets adjoining the spots consist not solely of hydrogen, but also of other substances, as is shown by their respective bright lines in the spectrum.
7. Among these bright lines which are commonly found at the base or in the lower portions of the jets, there are frequently seen those of sodium, magnesium, iron, &c., and constantly two lines in the red, one between C and B, distant from C $\frac{41}{100}$ of the space C—B; the other is between B and *a*, distant from *a* $\frac{86}{100}$ of the space B—*a*. These lines do not correspond with those of any substance yet known. They are also not infrequently seen quite bright in the highest parts of the jets.
8. Now and then the eruptions in the vicinity of the spots assume gigantic proportions, and are probably the cause of the

rapid changes of form and position which are observed in the spots themselves.

9. There are often seen, in the neighborhood of the spots, jets curved backward upon the solar disk in forms which are sensibly parabolic.

10. The immense jets and erupted masses near the spots expand and vanish away more rapidly than in any other region.

11. On the area of the spots neither the photosphere nor the edge of the sun's disk shows any perceptible irregularity, that is, neither any perceptible prominence nor depression.*

From these results obtained by spectroscopic observations of the border of the sun and of the protuberances, Prof. Respighi is led to certain conclusions relative to the physical constitution of the sun, among which the following may be mentioned.

In the first place, the photosphere would appear to be the surface of an incandescent liquid mass or stratum, of suitable specific gravity, by the weight of which various gases, and especially hydrogen, are confined and compressed in the interior of the sun, at an elevated temperature, under an enormous tension, and with a density differing but little from that of the superincumbent liquid stratum.†

These gaseous masses in the interior of the sun, not yet having been brought to a condition of stable equilibrium, might some portions be less condensed, and hence from hydrostatic pressure would rise toward the surface with great velocity, until, overcoming by their enormous expansive force the resistance of the liquid statum, they would burst through [illegible] with a velocity greater or less according to the depth from which they emerged, and the degree of tension in which they originally were, and would thus develop those jets or eruptions which constitute the protuberances.

The masses thus erupted, then, would not be determined in their movement solely by their initial velocity and the action of gravitation, but would generally be subjected to the operation of other forces which would concur in their elevation, their diffusion, and their ramification into those extraordinary forms which the protuberances present. According to this hypothesis, the hydrogen issuing from the body of the sun would serve as aliment to the chromosphere, repairing thus the rapid losses of the latter, by its not improbable combination with the substances of the photosphere; and it does not appear to Prof. Respighi absurd to suppose that this immense stratum of incandescent hydrogen, that is, the chromosphere, may be the principal source of the heat radiated from the sun.

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* See foot note on next page.

† See the article of Prof. Zöllner, translated from the Proceedings of the Royal Saxon Society of Sciences, June 2, 1870, published Nov., 1870, in the Philosophical Magazine, where substantially these views are stated at length, and thoroughly discussed.

In regard to the spots, spectroscopic observations appear to show that they are neither cavities nor clouds, but are merely superficial modifications,* that is, partial obscurations of the photosphere, produced probably, by scoria or scum floating upon it. On the contrary, regard being had to the well defined forms of the jets neighboring the spots, to their extraordinary subtilty, and to their enormous energy, the supposition does not appear to the author irrational, that the nuclei of the spots consist of portions slightly projecting from the photosphere, of solid masses or islands floating upon the liquid stratum which envelops the body of the sun. The immense chains of jets or protuberances, which rise ordinarily in the region of the spots, might be the cause of those great transformations which are observed in the latter, and determine, by their resistance in the superficial strata, currents in a direction opposite to that of the solar rotation, from which would result the proper motion of the spots themselves. The limits of an article forbid entering into the arguments by which Prof. Respighi endeavors to justify these conclusions, hypotheses, in great part at least, already advanced by others, but without that impress of plausibility and probability which they gain from the results of the spectroscopic observations discussed in this note.

The note is accompanied by four plates. Three of these represent 140 profiles of the sun, and the fourth contains sketches of some of the more remarkable protuberances observed by the author, and is the one accompanying this article.

On the plate, which contains 23 figures, the protuberances of approximately similar forms are grouped together. The observations were all made in 1870, and severally at the following times: No. 1, Aug. 12, 11^h; 2, Feb. 26, $10^h\ 40^m$; 3, Jan. 4, $1^h\ 15^m$; 4, Oct. 7, $2^h\ 50^m$; 5, Sept. 5, 1^h; 6, July 23, 10^h; 7, Jan. 17, $3^h\ 45^m$; 8, Nov. 12, $10^h\ 20^m$; 9, Nov. 25, $9^h\ 45^m$; 10, Jan. 24, $12^h\ 40^m$; 11, Oct. 25, $10^h\ 40^m$; 12, Dec. 2, 1^h; 13, Aug. 26, $6^h\ 15^m$; 14, Oct. 29, $11^h\ 30^m$; 15, Oct. 2, $9^h\ 45^m$; 16, Nov. 24, $3^h\ 48^m$; 17, March 11, $4^h\ 40^m$, 18, July 30, $9^h\ 16^m$; 19, Aug. 24, 12^h; 20, July 1, $2^h\ 25^m$; 21, Oct. 28, $1^h\ 24^m$; 22, April 18, $10^h\ 7^m$; 23, Aug. 23, 10^h.

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* This conclusion is entirely at variance with those of other observers, unless the author designedly omits the consideration of the penumbra, or makes no distinction between it and the umbra. The observations of Prof. Wilson in the last century, and of many others since, have shown that the nucleus or umbra is very often, if not generally, lower than the penumbra and the surrounding luminous masses. Some years since, Mr. De la Rue made a photograph of a solar spot, and another of the same spot after an interval of a day or two. When these were placed in a stereoscope the spot appeared funnel-shaped, the central portion being clearly lowest. Also Zöllner and Lockyer have found in the displacement of the lines in the spectroscope, that there is sometimes decided evidence of a downward motion, in the dark portion of a spot. In the remarkable article, previously referred to, published in the Phil. Mag., Nov., 1870, Prof. Zöllner says. "almost all observers agree in admitting that the umbra lies at a lower level than the surrounding parts. The depth at which the umbra lies has been ascertained partly by direct (De la Rue, Stewart, Lœwy), partly by indirect (Faye) observations, to be about 8″."

A. W. W.

ART. XLIV.—*Brief Contributions to Zoölogy from the Museum of Yale College.* No. XIII.—*Descriptions of new and imperfectly known Ascidians from New England*; by A. E. VERRILL.

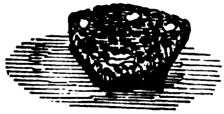
[Continued from page 212.]

Family, POLYCLINIDÆ.

Amouroucium glabrum Verrill, sp. nov. Figures 20 to 22.

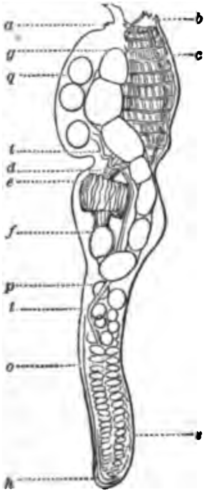
20.

21.



When young (fig. 20) this species forms small, clavate, or turbinate, translucent masses, attached by a narrow base, and containing only a few animals arranged somewhat irregularly around a single cloacal opening. The surface is smooth and glabrous, without adhering sand; the texture is rather firm, but so transparent as to distinctly show the animals, which are elongated and comparatively large, standing nearly vertically, with the ovaries extending nearly to the base of the mass. The intestines, filled with pellets of fœcal matter, appear as conspicuous, dark, oblique spots.

22.



Larger specimens (fig. 21) become ·5 to 1 inch or more broad and have a large attachment and expanding sides, with a more or less irregular, smooth upper surface, which is usually slightly convex. Several cloacal openings are irregularly placed on the upper surface, and numerous individuals are irregularly scattered throughout the mass, though often forming rather indistinct circular groups around the apertures. The surface is glabrous and the tissues translucent, as in the younger specimens.

The animals, when mature, are mostly about ·20 of an inch long, and about ·05 in diameter; but many are ·25 of an inch long and ·06 to ·07 in diameter. The thorax is longer and broader than the abdomen, and in specimens taken about the middle of August the cloacal chamber was distended by three to five large eggs, with the tadpole-shaped embryos nearly developed, while the post-abdomen was quite slender and the ovaries shrunken. Specimens obtained earlier (fig. 22) had the post-abdomen much thicker and filled with the large ovaries, in the upper part of which were eggs in various stages of growth, while the cloacal chamber

Figure 22.—*Amouroucium glabrum* Verrill, enlarged 10 diameters: *a*, anal orifice; *b*, branchial orifice; *c*, branchial sac; *d*, œsophagus; *e*, stomach: *f*, intestine containing fœcal pellets; *g*, anus; *h*, heart; *o*, ovary; *p*, eggs; *q*, eggs containing embryos in process of development; *s*, testes; *t*, spermatic duct.—Original, by A. E. V.

contained but few eggs, in which the development was but little advanced. The post-abdomen is usually but little smaller at base than the abdomen, and tapers gradually to the obtuse end; its length is generally less than that of the thorax and abdomen taken together, but often exceeds it. The stomach (*e*, fig. 22) is short and broad, with numerous longitudinal, glandular ridges. The intestine is large, and usually contains from 7 to 10, large, blackish fœcal pellets.

The branchial orifice (*b*, fig. 22) is surrounded by six, small, tapering papillæ. The anal orifice is somewhat bilabiate, the lower lobe being stout and broad, the upper longer and tapering.

The color of the masses during life, is pale, translucent, bluish white; the branchiæ are light yellow; the stomach dark orange; ovaries yellowish white; the eggs containing embryos bright orange-yellow.

Eastport Harbor and Grand Menan, low-water under stones, to 60 fathoms, stony and shelly bottoms, attached to stones, shells, ascidians, etc., common,—Exp. of 1861, '63, '64, '68, '70.

Amouroucium pallidum Verrill, sp. nov.

Masses sessile, hemispherical or subglobular, usually attached by a large base. Surface generally evenly rounded, sometimes irregular in large specimens, smoothish, but thinly covered with minute, firmly adherent particles of fine sand, which are imbedded in the surface of the common tissue and scattered throughout its substance. The texture is softer and more gelatinous than in the preceding species. The cloacal openings are few in number and irregularly placed, except in small specimens, which usually have but one large central opening. The animals are much smaller and more numerous than in the preceding species, often forming somewhat circular groups of six or eight individuals around the cloacal openings; outside of the circular groups they are usually irregularly scattered, but sometimes form linear series of eight or ten, and in young specimens with but one central opening they often form a larger outer circle, which is near the margin, more or less irregular, and composed of numerous individuals. Except in their much smaller size, the animals resemble those of the preceding species, though they are perhaps a little shorter and thicker in proportion. The post-abdomen, in all the numerous examples examined, was small, thick, obtuse, and decidedly shorter than the abdomen and thorax taken together; it contains few ovules in two series, and often terminates in two slender papillæ.

The larger specimens of this species are ·50 to ·75 of an inch in diameter; the largest animals are ·08 to ·11 long, by ·03 to ·04 of an inch in diameter, but many are much smaller than this; the largest one examined was ·15 long by ·05 of an inch in diameter.

The color of the masses, in life, is pale, translucent, grayish or bluish white, with yellowish white animals.

Eastport and Grand Menan, with the last,—Expeditions of 1868 and '70.

Amouroucium pellucidum Verrill.

Alcyonidium? pellucidum Leidy, Journal Phil. Acad. Nat. Sciences, 2nd ser., vol. iii, p. 142, Pl. x, fig. 25, 1855.

"Polypidom translucent white, attached by narrow fasciculated bases, which are extended in a procumbent manner and then expand into wedge-shaped masses, upon the free, flat surfaces of which the polyps are clustered. Polyps with bright orange colored tentaculæ.

Attached to rocks, mytili, sponges, etc., at Point Judith (R. I.); abundant.

The masses of *A. pellucidum* from the white, fasciculated points of attachment to the broad free surfaces are up to an inch in thickness. Although I preserved a number of specimens in fresh sea-water for some days, I could not induce the polyps, if they were such, to protrude from their cells, and I only had the opportunity of examining them in their retracted condition as represented in figure 24, plate x."

The figure referred to very well represents the thorax and abdomen of a species of *Amouroucium*, allied to *A. glabrum* V., except that the longitudinal ribs of the stomach were mistaken for the retracted tentacles of a Bryozoan, and figured as such. The post-abdomen is not shown, and was undoubtedly accidentally broken off in dissecting it out.

The cloacal cavity, or atrium, is represented as distended by four large eggs, containing well advanced embryos; the branchial sac has a broad dorsal and 12 transverse ducts; the intestine is like that of *A. glabrum*, and contained dark fœcal pellets; the branchial opening has six rounded papillæ; the anal has an elongated lobe above it.

Two specimens, dredged at Wood's Hole, Mass. by Prof. H. E. Webster, appear to be identical with this species. These form low, soft, broadly expanded and flat topped masses, up to 2 inches in diameter, and ·50 to ·75 thick, attached by the middle of the lower surface and proliferous around the edge of the base, which is surrounded by young colonies, composed of but few individuals arranged around a central orifice and covered externally with adhering sand. These young colonies are elongated, expanding to the truncate upper end, and ascend very obliquely, the outer ones remaining free, except at base, the inner ones coalescing more or less completely with the central mass. The common tissue of the upper side is very soft, gelatinous, translucent, with but little adhering sand; the sand increases toward the margin, and on the outer and lower sides nearly covers the surface. The individual zoöids are very numerous on the upper side, mostly arranged in rather irregular, elongated, elliptical or oblong systems, composed of many individuals of various sizes. The adult individuals are rather slender and elongated; the slender post-abdomen equalling or exceeding in length the rest of the body, but not more than half the diameter of the thorax and slightly constricted at base. In young individuals, not half grown, the post-abdomen forms nearly half the whole length, and is very slender. The branchial aperture has six, short, round papillæ; the anal is situated a short distance from the end of the body, and has short inconspicuous lower lobes, with an elongated, pointed lobe above. The branchial sac is oblong, with numerous longitudinal and transverse vessels and a broad ventral duct. The stomach is about as broad as long, subglobular, with the ends truncated and the surface covered with numerous, interrupted, longitudinal, glandular ridges. The post-abdomen is nearly filled by the large, elongated ovary, which extends nearly to the posterior end on the dorsal or atrial side, and contains numerous closely packed ovules of comparatively large size, and the conspicuous male organs, extending through the whole length on the ventral or branchial side, in the form of a slightly convoluted, dark colored duct. The posterior end terminates in a small, obtuse papilla. The atrium, or cloacal cavity, contains eggs in which the embryos are well developed, and in some cases the free, tadpole-shaped larvæ. The tunic is speckled with numerous, minute, purplish-brown pigment cells.

One of the larger adult individuals measured ·30 of an inch in length; thorax ·08; abdomen ·06; post-abdomen ·16; diameter of thorax ·031 to ·035; of abdomen about the same; of post-abdomen ·015 to ·020.

Amouroucium stellatum Verrill, sp. nov.

This species forms large, erect, crest-like plates or fronds, attached at the lower edge to stones and pebbles by short root-like extensions; the outer and upper edges are subacute or rounded, divided into two broad, rounded lobes above. The frond is 2·5 inches high, and about the same in breadth, the thickness varying from ·20 to ·35 of an inch. The tissue is firm and cartilage-like externally, softer within; surface smooth and glabrous, without adhering sand. The zoöids are arranged in nearly circular and pretty regular stellate groups, usually containing from six to fifteen individuals, arranged around a central sub-circular orifice; in contraction the position of each individual is indicated by an oval spot, more transparent than the common tissue, with a small flake-white spot around the branchial orifice.

The individual zoöids are elongated and slender; the post-abdomen more slender, usually considerably exceeding in length the rest of the body, and but slightly constricted at base; the thorax and abdomen are shorter and stouter than in the preceding species; branchial sac with about 12 transverse vessels; stomach oblong-oval, with numerous longitudinal glandular folds; intestine large. Branchial orifice with six short lobes; anal orifice terminal or nearly so, close to the branchial, with an acute upper lobe.

Color, in alcohol, milky white, subtranslucent; zoöids yellowish. One of the larger zoöids measured ·31 of an inch in length; the thorax ·085; the abdomen ·062; the post-abdomen ·165; diameter of thorax ·045; of post-abdomen ·025.

Wood's Hole, Mass.,—Prof. H. E. Webster.

This species is easily distinguished from all the preceding by its large, upright fronds, circular systems, and the regular stellate arrangement of the zoöids, and by its firmer texture and smooth surface.

Macroclinum, gen. nov.

Allied to *Aplidium*, forming thick, fleshy masses, of various forms; without cloacal openings or common ducts, each individual having its own branchial and anal orifices, side by side. Systems scattered, usually rather indistinct. Animals elongated, slender; post-abdomen narrow, much longer than the abdomen and thorax taken together, filled with voluminous ovaries, placed on each side of the median duct; eggs small and very numerous; stomach deeply lobed; intestine long, often convoluted; anal orifice terminal or subterminal, near the branchial, subcircular or somewhat bilabiate, the upper side with a rather prominent lobe; branchial with six rounded lobes or short papillæ. Type, *M. crater*.

Savigny included in his genus *Aplidium* two "tribes," each containing several species, but differing considerably in structure. In the first tribe, to which the name, *Aplidum*, should be restricted, the post-abdomen is short and rounded and the ovaries are clustered and contain few large ovules; the anal orifice is on the side of the thorax and distant from the branchial. The second tribe appears to correspond nearly with our genus, *Macroclinum*, the post-abdomen being very long, with the ovaries arranged along each side; but there is considerable diversity in the arrangement of the anal orifices, if

23.

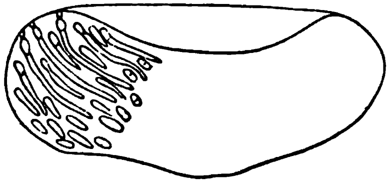


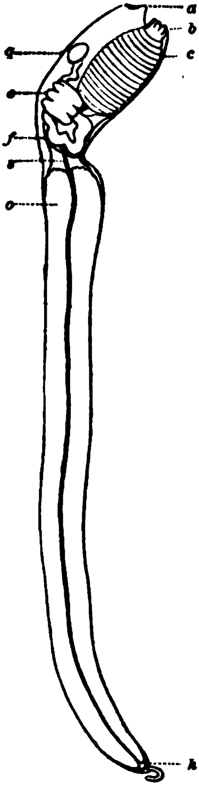
Figure 23.—*Macroclinum crater*, showing in outline a section through the middle, natural size. The animals are omitted on one side.—Original, by A. E. V.

correctly figured. The species are *M. effusum* from the Gulf of Suez, *M. gibbulosum* and *M. caliculatum* from Europe. *M. nutans* (Johns., sp.) from England, appears to be another species.

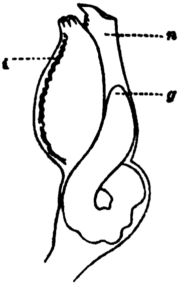
Macroclinum crater Verrill, sp. nov. Figures 23 to 25.

This species forms large, thick, gelatinous, but firm masses, which have a circular outline, with the upper surface deeply concave or cup-shaped. The surface is covered with a thin layer of closely adhering grains of fine sand, which are also diffused throughout the mass. The branchial and anal orifices are quite small, close together, and scarcely visible in the contracted state. Animals rather large, and pretty uniformly scattered through the mass, but in some parts forming large, irregular, somewhat circular groups. The thorax and abdomen are comparatively small, together usually less than one-fourth of the entire length; the branchial sac has about 16 transverse vessels, with numerous finer longitudinal ones; the branchial orifice has six small papillæ; the anal is terminal, and slightly bilabiate, with the lobe above it broad and usually recurved at the tip. The stomach, in most of the examples examined, was empty and badly contracted; it appears to be deeply lobed. The post-abdomen is very long and connected to the abdomen by a somewhat narrower, short pedicel. A conspicuous median duct extends the whole length, with the voluminous ovaries on each side. The ovules are very small.

24.



25.



The common mass is 1·75 inches in diameter, and 1 high; the largest individuals are ·50 to ·65 of an inch long, and ·06 to ·07 in diameter, at the thorax.

Color in alcohol translucent yellowish white; the animals light yellow.

Banks of Newfoundland,—T. M. Coffin.

Figure 24.—One of the individual animals, extracted and enlarged 7 diameters; *a*, anal orifice; *b*, branchial; *c*, branchial sac; *e*, stomach; *f*, intestine; *h*, heart; *o*, ovary; *q*, egg in process of development in the cloacal chamber or atrium; *s*, spermatic duct.—Original, by A. E. V.

Figure 25.—View from the opposite side, showing the thorax and abdomen of another individual, enlarged 10 diameters; *g*, termination of the intestine, which is filled with fœcal matter; *i*, ventral duct of the branchial sac; *n*, cloacal chamber.

With the last species Mr. Coffin otbained another, which is not well enough preserved to admit of accurate determination. It may be a species of *Amouroucium*, or another *Macroclinum*. It forms broad incrustations, 2 or 3 inches across and about ·25 thick in the center. The marginal portion is thin and covered with adherent grains of sand; the central part is smooth and glabrous, slightly convex. The zoöids are about ·30 long, with a long post-abdomen, which is not pedicellate, resembling that of *A. glabrum*.

ART. XLV.—*Amazonian Drift*; by Prof. CH. F. HARTT, of Cornell University.

PROF. AGASSIZ has claimed that the structure of the Amazonian valley is very simple; that, from one end to the other, there was laid down in the fresh water lake formed by the damming up of the mouth of the valley, by a glacial moraine, beds of sands, clays and sandstones, filling the valley to the height of several hundred feet above the present level of the river; that, from the bursting of the barrier and the draining of the lake, the uppermost beds were denuded down, and swept off from over a very great part of the valley, leaving only isolated outlines as a series of table-topped hills or serras, like those of Almeirim, Paraúquára, Velha Pobre; that the lake, reduced to a lower level, then threw down over the denuded portion, a sheet of clay, the river finally cutting its channel through this clay and the underlying sand, &c. He did not claim to have found grooved or striated surfaces in the Amazonas, and the only instance of supposed erratics he gives is that of the diorite found on the flanks of the serras of Ereré. Prof. Agassiz gave as a type of the table-topped hills the serra just mentioned. Last summer, in making an examination of the lower part of the Amazonian valley, I visited Ereré and spent a month in its vicinity going over the ground on foot in every direction, and in the most detailed way.

The serra does not belong to the system of table-topped hills of which Paraúquára and Velha Pobre are examples. These last and the range of highlands on the south of the Amazonian valley are composed of soft materials; they are perfectly flat on top and descend on all sides by a steep even slope; moreover, the strata composing them are horizontally disposed.

Ereré is a short, narrow, irregular ridge about 800 feet in height, several hundred feet lower than the table-topped hills, the top being anything but horizontal. The strata composing it are principally a heavy-bedded coarse white sandstone exceedingly hard, with bands of indurated feldspathic clay. These beds dip to the southeastward (approximately), with an angle in some places of 15 or 20°.

On the northern side of the serra and extending close up to its base is an extensive plain composed of a series of coarse shaly sandstones, shales, and cherty beds, quite horizontal, and not participating in the disturbance which the strata of the serra have suffered. These beds contain trilobites of the genus *Dalmanites*, with species of *Spirifer*, *Orthisina*, *Chonetes?*, *Discina*, *Lingula*, *Leptocœlia*, *Tentaculites*, &c. Specimens of these have been submitted to Prof. Hall who writes me that they indicate a horizon equivalent to the Upper Helderberg. The conclusion seems inevitable that the serra is pre-Devonian in age. The Devonian rocks of the plain are broken through by a perfect net work of dikes of trap now decomposed. The end of a curious low ridge that runs off at right angles from the serra consists of a large mass of trap. This has given rise to a great number of boulders of decomposition which lie on the surface or are buried in decomposed rock. They have been carried down the beds of torrents but they are nowhere erratics. To speak broadly, I did not see either at Ereré or in any part of the Amazonas, anything that would suggest glacial action. So far as the province of Para is concerned, the clays, sands, &c. forming the lower lands are far from being uniformly distributed, and are very puzzling to study. The arrangement of the materials varies in different regions, and many of the deposits are local. In part, the lower lands are formed from the wearing down of the great sheet of clays, &c., of which the Almeyrine hills are relics, in part they are of brackish or fresh water origin when the river stood at a greater height; and much is the very recent work of the river. The variegated clays belong to several distinct epochs. Superficially examined they appear to be universally distributed, but it is very far from being the case. It is impossible to recognize beds of clay in the Amazonian valley simply from lithological characteristics. It is sufficient to say that variegated clays of exactly the same appearance and structure, because formed of materials reworked or drawn from the same source, occur in the Devonian, Carboniferous, Tertiary and in half a dozen successive formations of recent times.

I have referred the beds of the table-topped hills to the Tertiary. Some of the clays and sandstones of the lower Amazonas may also be later Tertiary; but many are undoubtedly recent, they are full of leaves of modern species. Near Santarem I found a bed of recent fresh water mussels, *Castaleas*, *Hyareas*, *Unios*, &c., whose upper limit was at least fifty feet above the level of the highest Amazonian floods. This is in exact accord with the facts I have given elsewhere—being on the late rise of the Brazilian coast, a rise which extended itself into the interior. Before this rise the land stood much lower than at present;

the island of Marajó did not exist, and the Amazonas formed an estuary opening widely to the sea. Not only were the lower plains of Pará flooded, but immense tracts of the province of Amazonas were covered with water. How far this salt water penetrated I do not know, but the shells of Pebas show that at one time its influence may have extended far up toward the Andes. At the time of the growth of the Santarem shells the water may have been brackish. With the gradual rise of the continent, not of the Andes alone, the fresh waters drove down the salt, the narrow river bed with its numerous channels was hollowed out of the emerging bottom, the sea began to attack and cut away the coast lands, and the present estuary condition of the mouths of the great river was brought about. I have not yet told half the story of the history of the Amazonian valley. It is by no means a simple one, and there are more episodes in it than we have hitherto dreamed. The Amazonas is a world, and no one man need hope to exhaust its wonders.

Cornell University, Ithaca, N. Y., Feb. 23d, 1871.

SCIENTIFIC INTELLIGENCE.

I. CHEMISTRY AND PHYSICS.

1. *On some Lecture-experiments.*—(1.) To show the reciprocal combustion of the elements of water, JULIUS THOMSEN proceeds as follows: two narrow tubes of platinum, a centimeter long by a millimeter in diameter, formed by rolling up a piece of foil, are melted into the ends of two narrow glass tubes, and serve for the jets. These glass tubes pass through a rubber cork, distant from each other about a centimeter. One of them communicates with an oxygen gas-holder, the other with one containing hydrogen. The cocks of both are opened, the hydrogen is ignited and the stopper with its tubes, is introduced into a wide glass tube 10 or 15 centimeters long, slightly constricted at its lower end, and drawn to a narrow opening above. The hydrogen now burns in the oxygen, the platinum jets protecting the tubes. If now the oxygen be gradually shut off, a point will be soon reached where the amount present will be insufficient for the combustion of the hydrogen; the flame expands, and apparently disappears, but in an instant re-appears upon the oxygen tube, the oxygen now burning in hydrogen. On admitting more oxygen the flame passes over again to the hydrogen tube as at the first. This exchange may be repeated as often as is desired without extinguishing the flame and without danger, if the oxygen be let on and cut off with sufficient slowness.

(2.) To show that oxygen may burn with a smoky flame, Thomsen uses the vapor either of turpentine or of benzol. Some benzol is heated to boiling in a long-necked flask closed with a stopper, through which passes a central tube a centimeter in diameter, and also a small lateral one, bent to one side. The vapor is ignited at the mouth of the large tube, and a small tube recurved at its lower end, through which a stream of oxygen is passing, is immediately inserted, the opening being closed by a cork which slides upon the small tube. The flame of the benzol vapor is thus extinguished and the oxygen burns in the vapor in the flask, with a smoky flame. The excess of vapor passes off through the small lateral tube.

(3.) The processes of oxidation and reduction and the consequent changes in weight, Thomsen shows thus: cupric oxide is mixed with gum-water to a stiff paste and formed into cylinders, flattened on their sides, about a centimeter in diameter and 3 centimeters long. These are then dried, ignited, and reduced by hydrogen at the lowest temperature possible. A cylinder of metallic copper is thus obtained, very porous but sufficiently coherent to retain its form. These are wound with platinum wire, the two ends of which are melted into glass tubes by which they are handled. Two small tubulated glass bells are filled, the one with hydrogen, mouth downward, the other with oxygen, mouth upward, by displacement, the gases being allowed to flow slowly into them during the experiment. One of the copper cylinders is warmed to expel moisture, and immersed in the oxygen; it is raised at once to ignition and remains so until completely oxidized. It is then plunged into the bell-jar of hydrogen; it again begins to glow, the water formed runs down the side of the bell, and the cylinder is reduced to copper again. These combustions, the one in oxygen, the other in hydrogen, both evolving much light and heat, are very striking; and as the increase in weight of the cylinder by oxidation is almost a gram, it may be shown on an ordinary balance.—*Ber. Berl. Chem. Ges.*, iii, 930, Dec. 1870. G. F. B.

2. *On Ozone and Antozone.*—Engler and Nasse have investigated the production of antozone by the method of Meissner (this Journal, II, xxxvii, 325, xxxviii, 18, l, 213). They used an ozonizing tube 85 centimeters long, containing 28 wires enclosed in glass, and a coil sufficiently powerful to render the entire bundle of electrodes luminous in the dark. If the ozonized oxygen be passed through a U-tube 30 centimeters long and one centimeter in diameter, containing zinc-sodium in fragments, the ozone odor disappears completely. If the same tube be placed between the potassium iodide solution and the water over which the cloud appears, the formation of the cloud is not interfered with; thus showing that it is only the ozone and not the antozone which is destroyed by the zinc-sodium. Since Meissner concedes that the ozone must be removed to detect the antozone, it follows that were the antozone formed in the electrizing tube, the gas issuing from it after passing through the zinc-sodium tube and thus being deprived of ozone, should, on bubbling through water, produce a cloud; but this the authors find not to be the case. Moreover, they show that if the stream of oxygen issuing from the potassium iodide solution be passed through a tube 1·3 meters long,

filled with fused calcium chloride, the antozone disappears; while ozone passed through such a tube is unaffected. But if the gas from the ozonizing tube be passed directly through this calcium chloride tube, then through potassium iodide solution and then through water, the cloud appears with full strength. Engler and Nasse hence infer that the antozone is formed when the ozone is destroyed in presence of water; and only then. Whence they conclude with v. Babo and Weltzien, that antozone is only hydrogen peroxide. In support of this view they give the following experiments: (1.) The stream of electrized oxygen, deozonized by a solution of potassium iodide, was passed through a spiral tube 1·5 meters long, and found to give the mist on passing through water. This spiral was then heated in a zinc chloride bath; as the temperature rose, the mist formed became less and less, disappearing completely at 170°, and returning again as the tube cooled. (2.) The stream of deozonized oxygen was passed through a short tube containing fragments of potassium hydrate, and then through four narrow tubes 60 centimeters long filled with glass-fragments; but its mist-forming power was hardly weakened; when these tubes were cooled to $-20°$, however, no mist appeared on passing it through water; and when two narrower and empty tubes were used, and the stream of gas continued for 24 hours, water condensed in them which gave the reactions of hydrogen peroxide. In conclusion, the authors show that the division of oxides by Schönbein into ozonides and antozonides is not well founded.—*Ann. Ch. Pharm.*, cliv, 215. G. F. B.

3. *On the Peroxides obtained by Electrolysis.*—WERNICKE has analyzed the metallic films deposited upon the positive electrode in the electrolysis of solutions of certain metals. The following are his conclusions: (1.) The so-called peroxides, deposited by electrolysis from neutral or alkaline metallic solutions, are hydrates of the composition $R''\Theta, H_2\Theta$ or $(R_2)^{vi}\Theta_3, 2H_2\Theta$. (2.) The composition and the specific gravity of the bodies examined are as follows:—

Perplumbic hydrate,		$\mathrm{Pb}\Theta_2, \mathrm{H}_2\Theta$	6·267
Permanganic	"	$\mathrm{Mn}\Theta_2, \mathrm{H}_2\Theta$	2·564–2·596
Perbismuthic	"	$\mathrm{Bi}\Theta_2, \mathrm{H}_2\Theta$	5·571
Percobaltic	"	$\mathrm{Co}_2\Theta_3, (\mathrm{H}_2\Theta)_2$	2·483
Pernickelic	"	$\mathrm{Ni}_2\Theta_3, (\mathrm{H}_2\Theta)_2$	2·741

(3.) In thin layers these bodies exhibit the most beautiful interference-colors, which may be made available for the estimation of the refraction and dispersion of light. For purposes of technical metallochromy, the new colors of percobaltic hydrate are particularly to be noted, on account of the facility of their production and their permanence. (4.) All of these compounds are formed only with a weak current. If it be too strong, the precipitate thrown down on the positive pole contains less oxygen; until with a certain strength of current, oxygen only is evolved, the metal in the solution being unaffected. In this latter case the author supposes hydrogen peroxide to be formed, which decomposes the metallic perhydrate.—*J. pr. Ch.*, II, ii, 419, Dec. 1870. G. F. B.

4. *A Laboratory Text-book of Practical Chemistry; or Introduction to Qualitative Analysis.* A guide to the course of Practical Instruction given in the Laboratories of the Royal College of Chemistry. With 90 engravings. By WM. G. VALENTIN, F.C.S. 8vo, pp. xii, 380. London, 1871. (John Churchill & Sons).—One of the chief difficulties, which beset the chemical instructor at the present day, is that of satisfactorily combining didactic with practical instruction; of teaching by text-book recitation on the one hand, and at the same time, of instructing by laboratory experimentation on the other. While it is unquestionably true that Chemistry cannot be properly learned solely by committing a volume to memory, it is equally true that it cannot be mastered by working solely with apparatus. Both the intellectual and the manual discipline are necessary. In the book before us, the author, fully recognizing these two phases of the subject, has attempted to combine them. We have here not a dry enumeration of facts, to be proved by experiment and then stored up individual and alone. Nor on the other hand, have we a book to be memorized and recited from, parrot-like. "It has been the author's endeavour," he says in his preface, "to enter only so far into theoretical considerations as was absolutely necessary to explain the laws which govern chemical changes, and to make the beginner practically familiar with the properties of elementary matter, and the most important forms of combination."

The work is divided into two parts. Part First consists of "100 elementary exercises, introductory to General Chemistry and to Qualitative Chemical Analysis." Part Second is a course of Qualitative Analysis proper. In the first part, the student begins by performing simple and clearly discribed experiments with hydrogen and continues with oxygen, sulphur, chlorine, etc., and their compounds, the theoretical knowledge being gradually worked in as it is required. In the second part the usual division of the bases and acids into groups is followed, the whole being well arranged. Frankland's notation, wherein every chemical compound is formulated upon the type of the highest equivalence of its dominant atom, is used throughout. The atom of highest combining power in every molecule, is written first in heavy full-faced type, thus, $\mathbf{N}O_2Ago$, $\mathbf{S}O_2Zno''$, $\mathbf{B}Nao_3$, etc. Graphic formulas are also freely employed. At the end of each chapter in both parts, are questions for examination, which are remarkably full and thorough. The reactions in all cases are given, and all the facts which help the student to a complete knowledge of the substance under examination are fully stated. Frequent examinations are recommended, and these are to be conducted like recitations. Copious tables in the appendix contain a condensed statement of the analytical processes, of the solubilities of salts, and of the metric system of weights and measures.

We have rarely seen a better book to teach from than this. In its plan and the mode of carrying it out, its clearness, thoroughness, accuracy and attention to detail, it is, in our view, one of the best works of its kind in the English language. The wood-cuts are excellent and the style of the book is mechanically unexceptionable. G. F. B.

5. *A Series of Chemical Problems for use in Colleges and Schools. Adapted for the Preparation of Students for the Government Science and Society of Arts Examinations;* by T. E. THORPE, Ph.D., Professor of Chemistry in Anderson's University, Glasgow, with a Preface by Professor ROSCOE, B.A., Ph.D. F.R.S. 67 pp. 16mo. London, 1870. (MacMillan; Manchester, James Galt & Co.)—This little volume contains an excellent collection of practical problems, such as every chemist has to deal with, founded upon the modern nomenclature and notation, with simple formulæ for their solution, and systematically and very clearly arranged. The best and most recent determinations are employed as data, and an appendix contains a number of very useful auxiliary tables of physical and chemical constants, logarithms, &c. The exercises relating to specific heat, latent heat, calorific power, and calorific intensity are especially fresh and valuable. The volume is well calculated to serve both as an aid to the student, and as a practical reference book. A. W. W.

II. GEOLOGY AND NATURAL HISTORY.

1. *California Geological Survey.*—Ever since the first inauguration of this great work (in 1860), we have from time to time given our readers accounts of its progress, reporting the results of its explorations and the appearance of its publications, calling attention to the high ability and excellent spirit with which its labors were carried on, and expressing our hearty desire for its continuance, and completion upon the scale on which it was begun. Only two months ago (above, p. 70), its last published report was noticed in this Journal—the first volume of Ornithology, containing the land birds of the western side of the continent. Since then, the edition of the same with colored figures has appeared, and fully justifies the expectations entertained of it. The plan of giving highly colored illustrations in the text itself, on the same page with the letter-press, is quite new, and its success, which is complete, will be likely to make an era in the history of illustrated works on natural science. The admirable quality of the paper used, and the skill of the colorist, have united to produce a result which must satisfy the most critical taste.

The second volume of Ornithology, which will contain the water-birds of the whole country, is in process of preparation. The volume of Conchology, which Dr. Carpenter undertakes, is likewise begun; and Prof. Brewer of Yale, formerly assistant on the survey, is rapidly working up the botanical material for publication, aided by Prof. Gray, and by others specially qualified for the work. The abundant collection of mammalian fossils is committed to Dr. Leidy for treatment. The fossil botany is undertaken by Prof. Lesquereux. The volumes already issued contain descriptions and figures of the invertebrate fossils by Mr. F. B. Meek and Mr. W. M. Gabb. It thus appears that Prof. Whitney has called to his aid the best available talent in working out the results of the survey in special departments. Meantime, the field-work, and the elaboration of the geological and topographical data collected, are going on rapidly under his direction.

The necessity of preparing maps for the accurate delineation of the geology of a vast state of almost unknown geography, has led to an expansion of the topographical work far exceeding what was anticipated, and constituting a step of very great importance in the history of American geography. Accurate detailed maps, from actual surveys, of extensive inland regions, including grand mountain features, had not been produced before in the country, at least on anything like the same scale. Nor has the beneficial activity of the survey in this direction been limited to California; the survey of the 40th Parallel is to be accounted one of its fruits, the two heads of the latter, Messrs. King and Gardner, having begun their Western work in California under Prof. Whitney, and undertaken their survey in continuation and completion of his. Of the maps of the California survey, there have appeared hitherto those of the Yosemite valley and of the High Sierra in its vicinity (in the Yosemite Guide Book), and that of the region adjacent to the Bay of San Francisco, the last on a scale of two miles to the inch; a much larger map, including about 60,000 square miles of the central part of the State (occupied by more than nine-tenths of its population), is far advanced, one of its four sheets (the S.W. corner) being already engraved, and a second (the S.E. one, containing the highest part of the Sierra) in the engravers' hands. This is on a scale of six miles to the inch; it will be issued in duplicate, as geological and as a topographical map. Another, of the whole State, at eighteen miles to the inch, is finished, and is intended to serve as a preliminary geological map, and to accompany the second volume of geology, of which the printing will be begun next summer. Among the regions which have been recently receiving particular attention is that of the ancient river-channels, on the western slopes of the Sierra, which a party has for a long time been engaged in exploring and mapping, and on which a full report is soon to be made; also, the White and Inyo ranges of mountains, east of the Sierra and of Owen's valley; and the vicinity of Clear Lake, in the northern coast ranges.

We cannot express too strongly our sense of the importance of this survey, and of its value to the people of the whole country as well as of the State which it particularly concerns. That, after its temporary suspension (1868–70), it was taken up again and vigorously pushed, is highly creditable to the enlightenment of the California people; and it is not to be believed that they will again falter in the support of a work which is bringing them so much honor throughout the world, and helping to lay a sure foundation for the future successful development of the resources of the State.

2. *Geological Survey of Illinois: A. H. Worthen, Director.* Vol. IV. *Geology and Paleontology. Geology, by* A. H. WORTHEN, *and Assistants* H. M. BANNISTER, FRANK H. BRADLEY *and* H. A. GREEN: *Paleontology, Section* 1, *Descriptions of*

Vertebrates, by J. S. NEWBERY *and* A. H. WORTHEN; *Section* 2, *Description of Plants, by* LEO LESQUEREUX. 508 pp. royal 8vo, with 31 plates.—Much has been done in this country in the way of Geological Surveys. Yet only two States east of the Rocky Mountains have carried forward such surveys to anything approaching a worthy completion. These two States are New York and Illinois. Fortunately they supplement one another, so that a geologist, by possessing the reports of the two, when they are finished, will have quite a good account of the rocks and fossils of the whole range of the Paleozoic formations of the country. New York carries forward the subject to the Coal formation, while Illinois gives much that is new from the earlier limestones, and continues the geology through the Carboniferous period, in which part of the series the State is particularly rich.*

The fourth volume just issued is, like its predecessors, a handsome volume, and full of valuable material. Most of the counties here reported on are within the coal basin; and the reports are full of local details of Coal-measure sections—highly important to the local student and to capitalists interested in coal and iron, but including few matters of general interest. A hasty glance shows that the coal tonnage of these counties is immense, being approximately as follows:—Adams county, 830 millions of tons; Brown, 400 millions; Schuyler, about 1750 millions; Fulton, 7000 millions; Morgan, 3000 millions; Cass and Menard, 4000 millions; Tazewell, McLean, Logan and Mason, 30,000 millions; Grundy, 900 millions; Will, 66 millions; Kankakee, 40 millions; Vermillion, 4000 millions; Edgar, 6000 millions; Champaign and Ford, 10,000 millions: total, 70,000 millions of tons.

As matters of especial scientific interest, in the county reports, we note particularly various details and discussions touching the Loess; the Drift, with its included or antecedent beds of ancient swamp muck; the shallow artesian wells of the gravel of Iroquois county; the ancient channel [probably of a glacier] now filled with Drift, which runs south from the southern extremity of Lake Michigan; the outlines, level and drainage of "Lake Kankakee;" and the old outflow of Lake Michigan by the valley of the Desplaines and Illinois rivers. It is to be regretted that a map proposed for the purpose of showing details on these latter points could not be published with the volume, "for the lack of means to defray the expense of engraving," even though "the most essential parts of it will be transferred" to the large map of the entire State, now in course of preparation. Details are given, touching the unconformability of the Coal measures with the Subcarboniferous, and of the Devonian (or Subcarboniferous) with the Silurian.

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* The most of the other States have had surveys in progess; but, in general, in spite of the earnest protest of those interested in the work, they have been cut short when only a fair beginning had been made. Pennsylvania has done the best among these States; but still its extended Report, very valuable as far as it goes, includes no volume illustrating with plates the fossils of its rocks, the Coal plants excepted. Massachusetts has done much, but there is much more to be done; and the same is true of other States.

The equivalency of the different coals of the Illinois and Wabash valleys seems to be still in question; and we shall look with great interest for the thorough discussion of this subject which Prof. Worthen will doubtless give before closing his work.

The second part of this volume is occupied with descriptions and plates of fossils--Fishes and Coal-plants. Many new and interesting forms are described and figured. Prof. W. also notes the existence in his collections of enough of ichthyic fossils, as yet undescribed, to carry his catalogue of Illinois Carboniferous fishes to "something over two hundred species."

Mr. Lesquereux, after describing many new Coal-plants, and adding much to our knowledge of previously-described species, closes with an interesting discussion of facts regarding our American Coal-flora, which we shall notice more fully hereafter.

Prof. Worthen promises to complete this series of reports with two more volumes, most of the material for which is ready for the printer. We learn that the *fifth* volume will contain plates of the most important and beautiful series of Carboniferous crinoids and other echinoderms that has ever been figured or described. Very many of the figures have been carefully drawn, with many details of their structure, by Mr. F. B. Meek, and the remainder by Mr. Charles K. Worthen (son of the Director of the Survey), under Mr. Meek's direction. Including some of fishes there will be about forty plates.

3. *Burning of the State Geological Rooms at Springfield, Illinois.*—On the night of the 22d of February, (after the 4th volume of the Illinois Geological Report, above noticed, was received by us,) the building containing the State Geological Rooms and Collections was burned. The fire took in a book-bindery adjoining, and, "in five minutes after the alarm was given, the upper part of the building was a sheet of flame." Prof. Worthen's son, who was sleeping that night in the office, succeeded in removing all his father's library and private cabinet, before it became necessary for the engines to play upon the building. The State Collections, which contained the most complete series of Carboniferous fossils in the country, if not in the world, besides numerous other species, and many kinds unknown elsewhere, were greatly damaged by water and by hasty removal, and very many fine specimens were ruined. Since the fire they have been transferred to the basement of the new Post-Office building, which, as it is fire-proof, is safe against such disasters, and where they ought to have gone long before the fire. Fortunately, the copies of the 4th volume were in the hands of another book-binder and escaped.

This is another warning to all States, Societies or Institutions, having valuable collections, libraries or records; there should be no rest among the friends of learning until fire-proof buildings are provided for such objects. The money argument, that such a collection as that of Illinois would bring in the market over $20,000, has much force. But this amount in dollars is only a fraction of the real value to science, or to the people of Illinois.

4. *Report of the Geological Survey of Iowa*, under Prof C. A. White, Vol. II, 444 pp. 8vo.—The first volume of this report is noticed on page 217. The second volume contains a well prepared and instructive chapter, of 186 pages, on the Geology of the Middle region of Western Iowa and other counties by O. H. St. John, and reports on northwestern, and the middle region of northern, Iowa, and on the Coal counties, by Professor White, occupying nearly 100 pages. Prof. White next treats of the economical products of the State, exclusive of coal. Then follows the valuable chemical report of Prof. Rush Emery, containing analyses of rocks, coals, peats, etc. Those of coals are numerous; they have special reference to the economical value of the coals, and give the amount of moisture, volatile combustible, fixed carbon and ash. Prof. Emery compares the analyses with those of the coals of Illinois, and observes that the amount of moisture is perhaps a little in favor of the Iowa coals; the amount of ash is almost the same; that of fixed carbon is largely in favor of Illinois; while that of the total combustible matter is in favor of Iowa. The volume closes with a table of altitudes, and a catalogue of birds. The volume contains also a colored geological map of the State by Prof. White.

5. *Historical notes of the Earthquakes of New England*, 1638—1869; by William T. Brigham, A.M., A.A.S. 28 pp. 4to. From the memoirs of the Boston Society of Natural History, vol. ii, page 1.—This important memoir by Mr. Brigham aims to give a list of all the well authenticated earthquakes that have occurred in New England, with such notes as could be gathered from the records of the time. The number catalogued as having been felt over New England since 1638, eighteen years after the landing of the Pilgrims at Plymouth bay, is 227. Besides these, four earlier ones are mentioned from the traditions of the Indians. These were distributed through the months as follows:

Oct., 19; Nov., 29; Dec., 22; Jan., 20; Feb., 36; Mar., 22 . . 148
April, 9; May, 13; June, 14; July, 13; Aug., 15; Sept., 10 . . 74
No month given, ... 9

A considerable number of these earthquakes were felt over all New England, some of them also over Canada, and a few had wider limits. Many of them were comparatively local in their range. Three such local regions are deduced by Mr. Brigham from the catalogue. These are—1. A region in Canada, somewhat elliptical in form, with the city of Montreal as its western focus. 2. A region around the mouth of Merrimack river, in New Hampshire and Massachusetts and extending to Boston. 3. A region smaller than either of these, around New Haven, Lyme and East Haddam.

The author makes some suggestions with regard to the origin of the earthquakes, proposing to take up the subject in full at another time. He thinks it probable that there have been volcanoes somewhere in New England, prefacing his remarks by the statement that our Geological Reports have often been prepared by those who had never studied active and extinct volcanoes, and adding a remark implying that if Percival had ever "seen a volcano," he would have found them in the trap region of Connecticut. In reply to this we would state that no region of igneous rocks, volcanic or otherwise, was ever studied with more care, or with a more exact determination of the facts, than that of Connecticut by Percival. We have followed him over and among the various trap ridges of the Connecticut valley, and know positively that the trap eruptions were in all cases, eruptions through fissures, as Percival states, and not by volcanoes. We deprecate this throwing doubt over the accurate observations of others, by one who acknowledges that he knows nothing about the facts.

There are beds of scoriform rock in the Connecticut valley among the stratified beds in the vicinity of the trap. They occur near New Haven. A remarkable locality exists in Durham, on the Air-line railroad, under a bridge just east of Reed's Gap (a gap in the trap hills). At this place, the layer *seems* to be made up of large masses of scoria, some of them from four to six inches in diameter. But on a careful examination by the writer, the rock proved to be nothing but a scoriform sandstone, particles of quartz, feldspar and other ingredients of the Mesozoic sandstone being visible throughout the scoria masses, and manifestly constituting them. It is obviously a bed, like others at New Haven, through which steam penetrated freely during the trap eruption.

Mr. Brigham also suggests that the formation of trap dikes may now be going on, from time to time, at various depths below the surface; and "that the high temperature they bring in contact with the cold rock, through which they break, or into whose cavities they run, produces the tremors and disturbances we call earthquakes." But there is not an observed fact that authorizes us to believe that any eruption of trap has taken place in New England since the Mesozoic era. Moreover, earthquakes are not produced by the escape of igneous rock. An earthquake is the jar from sudden fracture or displacement; it matters nothing whether igneous ejections follow or not. The breaking of the rock begins the "tremor" if not already initiated. The earthquakes of New England may have resulted from a slight yielding to tension in the rocks somewhere beneath the region shaken, a tension that may be a consequence of former upheavals or subsidences of the region, or of unappreciated movements that are now in progress; or possibly of contraction or expansion below due to subterranean change of temperature; and some of the more local may come from a yielding to gravity in rocks beneath, if openings or cavities there exist. J. D. D.

6. *Preliminary notice of a new species of Trimerella, from Ohio;* by F. B. Meek. (Communicated by the author).—Among the fossils obtained by the Geological Survey of Ohio (now in progress under the direction of Prof. Newberry), and handed me for study, there are from the Niagara group some large casts of a *Trimerella*, which I had thought might be a variety of *T. grandis* Billings. On comparing them recently with Mr. Billings's typical specimens of that species, I have found them quite different and distinct. They are proportionally much broader shells, and differ in having the beak of the dorsal valve strongly incurved beyond

the plane of the connecting edges of the two valves. They are also more convex, the ventral valve is more arched, and the rostral davity of the dorsal valve deeper. The whole length of the shell must have been nearly 4 inches, the breadth 2½ inches, and the co vexity about 1½ inches. A description, with illustrations of the species (which I propose to call *Trimerella Ohioensis*), will appear in the Ohio Geological Report.

7. *The Phosphate Rocks of South Carolina;* by Francis S. Holmes, Charleston, S. C.—In the notice that has been given of this pamphlet, its views are not correctly represented. The author observes that the "Phosphate rocks" have been derived by denudation from an older formation, viz: the Eocene Marl. He states further that the beds of "phosphate rocks" thus produced contain the remains of various Post-pliocene land-animals, and are therefore Post-pliocene in age. He concludes that in that era the regions of these deposits along the coast were in the condition of salt-lakes or lagoons and were frequented by the Post-pliocene land-animals—"the Elephant, Mastodon, Rhinoceros, Megatherium, Hadrosaurus [?, the Hadrosaurus is a Cretaceous reptile], and other gigantic quadrupeds"—in great numbers, periodically, to sip the brine, or later to lick the salt, the areas serving as "salt-licks;" and that these animals left there their excrements and bones. The author holds that the former was the principal source of the phosphatic material, the bones adding only a small part; and that the excrements of birds did not contribute to the formation. He also remarks upon the change of the carbonate of lime of the rocks into phosphates by the waters percolating through them from the overlying fœcal layer,—a process referred to by J. D. Hague in this Journal, vol. xxxiv (1862), and by Mr. Julien in vol. xxxvi (1863), and vol. xl (1865).

8. *South African Diamonds.*—The diamond shipments from South Africa during the last two years have been as follows, according to the official return published in the *Standard and Mail* of the 4th of January: Shipped during 1869, 141 diamonds, valued at 7,405*l.*; during 1870, 5,661 diamonds, valued at 124,910*l.* To these must be added the "Star of South Africa," and some others sent by private means to Europe, valued at nearly 15,000*l.* A large number of the Cape diamonds now in London are of an inferior description; and we are informed by a large dealer in this gem that none of them are equal to the old Golconda gems.—*Athen.*, Feb. 18.

9. *Sciadopitys verticillata* of Siebold and Zuccarini is a Japanese Coniferous tree of considerable interest, as well from the peculiar structure of its leaves, as from the striking appearance of the verticillate foliage. Von Mohl, in the first two numbers of the *Botanische Zeitung* for 1871, has made an interesting exposition of the peculiarities of these leaves, and of the light they throw upon the morphology of Coniferæ. The cotylodons and the succeeding whorl consist of normal leaves. The rest of the foliage consists of double leaves, i. e. of two leaves united into one body emarginate at the apex, and subtended by a minute scale;

each, therefore, answers to a bundle of pine-needles, on a secondary axis, but without the sheath of scales, and the pair of leaves connate. Mohl shows that the anatomical structure bears out this view, and, moreover, that these two lateral leaves are so united that their upper face is turned downward as respects the main axis, the lower upward. Now Braun and Caspary, as is well known to morphological botanists, have drawn from the study of abnormal cones of Larch the conclusion, that the ovuliferous scales of *Abietineæ* equally consist of two connate carpellary scales; and these also present their normally upper face downward, their lower face upward; so that it is what answers to the under surface of the leaf that bears the ovules, as it is the under surface that bears the fructification in Ferns. A. G.

10. *Musci Appalachiani: Specimens of Mosses collected mostly in the Eastern part of North America;* by C. F. Austin. 1870.—We have thus far seen only the *tickets* of this collection, which are collected to form a pamphlet of 92 octavo pages, including a complete index. There are 450 numbers, and a few intercalations, and there are Latin characters of a considerable number of new or critical species. Although the collection of the Mosses themselves is, we believe, not yet issued, it is likely to be so before this notice is published; and we will take the liberty to announce the publication as one of large extent and of unsurpassed value. The limited number of sets makes it likely that they will be taken up almost at once. A. G.

11. *Report on the Progress of the State Geological Survey of Michigan;* presented Nov. 22, 1870, by Alexander Winchell, Director. 64 pp. 8vo. Lansing, 1871. Published by authority of the State.—We propose to notice this report in the following number.

12. *Annual Report of the State Geologist* [G. H. Cook] *of New Jersey, for the year* 1870. 72 pp. 8vo. New Brunswick, 1871.—This report is occupied mainly with matters of economical interest connected with soils, reclaiming marshes, fixing shore sands, etc.

III. ASTRONOMY.

1. *Transit of Venus in* 1874.—The following letter from Prof. Asaph Hall, of the U. S. N. Observatory, dated Feb. 25, 1871, is gladly published, in view of the importance of early and full deliberation with respect to the approaching transit of Venus.—Eds.

I would ask the attention of American astronomers to the approaching transit of Venus, that will occur Dec. 8th, 1874.

The memoirs published by Airy, Hansen, Oppolzer and others on the theory of this transit, and the maps which they have given for the selection of observing stations, render superfluous, perhaps, anything further on this part of the subject. What seems to me of the greatest importance is the union of all the American astronomers, in order that they may act in harmony and so that their observations at the various stations shall be made with similar instruments and in accordance with a preconcerted plan. The importance of such united and harmonious action will be acknowledged, I think, by any one who has ever reduced and discussed observations of this kind, for example, those of Mars made in 1862. I am confident that it is only by such action, and by careful, thoughtful and deliberate preparation, that the American observers can obtain results comparable in accuracy with those that will be obtained by the German expeditions. I venture, therefore, to suggest the following plan of operation.

Let the National Academy and the American Association for the Advancement of Science, at their next meetings, invite the attendance of the Directors of all the astronomical observatories in the country, and of all who are engaged in astronomical pursuits, theoretical or practical. Let these astronomers discuss and decide upon the stations to be occupied and the methods of observing the transit. They should appoint committees who should have charge of procuring instruments, selecting the observers and making preparations for paying the expense of the expeditions. Besides the scientific advantages to be gained, the hearty coöperation of our astronomers, in the solution of such a problem, will bring about mutual acquaintance and recognition of each other's abilities.

The first meeting of the commission convoked by Chancellor Bismarck for considering the approaching transit of Venus was held at Berlin, Oct. 25th, 1869. This commission consists of Hansen, president, and of Argelander, Paschen, Bruhns, Förster, Auwers and Winnecke; all experienced astronomers except M. Paschen, appointed for his knowledge of photography. Afterward the commission invited to join in its deliberations Dove of Berlin, on account of his knowledge of meteorology, Prof. Zöllner of Leipsic for his knowledge of spectroscopic observations, and Otto Struve, Director of the Pulkowa Observatory. The early action of the German government and its wisdom in putting the matter into the hands of experienced astronomers are much to be commended. We may not be able and may not wish to follow the methods proposed by the German astronomers, but we must have prompt, deliberate, and concerted action, if we would obtain good results.

2. *On a Meteor seen at Konisha, Minn.;* by THOS. M. YOUNG. (From a letter to Prof. Henry, Secretary of the Smithsonian Institution, and communicated by him).—I have the honor to report that a meteor exploded over this place at 2·20 P. M. on Saturday, February 4, 1871.

The aërolite seemed to come from the north of east, and when it reached a point about four degrees north of west of this place, lat. 45° 10 long. 94° 10′, and at an elevation of about 38°, it exploded with a detonation like the combined roar of a park of artillery; the concussion was so great as to shake houses. I have heard from four different points on a base line, 42 miles long, and observers at these points were not able to notice any divergence from the general direction of N. 86° W., consequently the distance must have been great to the point at which the aërolite exploded.

3. *Fall of Meteoric Stones at Concord, Ohio.*—Accounts of the fall of fragments of a meteorite in Guernsey Co., Ohio, are published

in volume xxxi, at page 87, 1861. The following is an additional notice of the same fall, from the Zanesville Courier of May 5, 1860, communicated for this Journal by Prof. HENRY.

An extraordinary phenomenon occurred on Tuesday, May 1, about noon, which has been noticed in many counties in Eastern Ohio. This occurrence, although it may be incredible to some, was certainly noticed by many in different localities about the same time. In this city the explosion, or noise, was distinctly heard. At New Concord, 16 miles east, a gentleman, who was out in his field, heard a loud crash, similar to sharp thunder; a succession of such crashes lasted for about half a minute and then died away, like the sound of a receding train of cars. On looking up, he observed an object descending with great rapidity, and on marking the point where it touched the earth, he there found a stone imbedded two feet in the earth, and somewhat warm, weighing 52 lbs. Another was found of 56 lbs., one of 40 and one of 36 lbs. in weight, all within the circumference of a few miles.

IV. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Recent Auroral displays in the United States.*—In vol. 50, p. 146, (July, 1870), we have given the dates upon which Auroras were reported, by at least one of the observers of the Smithsonian Institution for the year 1869, and for three months of the year 1870. We now continue these observations to the close of the past year.

1870.
April 1, 2, 3, 5, 6, 7, 8, 12, 15, 16, 18, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30. Total, 21 days.
May 1, 2, 3, 6, 7, 9, 13, 14, 15, 17, 18, 19, 20, 22, 24, 25, 26, 27, 28, 29, 30, 31. " 22 "
June 3, 6, 14, 15, 16, 17, 18, 19, 20, 23, 24, 26, 27, 30. " 14 "
July 1, 2, 3, 5, 6, 10, 13, 14, 15, 16, 18, 19, 23, 24, 25. 27, 28, 29, 30, 31. " 20 "
Aug. 2, 4, 7, 12, 13, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31. " 19 "
Sept. 3, 4, 6, 7, 8, 11, 12, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 30. " 21 "
Oct. 1, 3, 11, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 31. " 21 "
Nov. 3, 8, 9, 12, 13, 14, 16, 17, 18. 19, 21, 22, 23, 24, 27, 28, 29, 30. " 18 "
Dec. 1, 4, 6, 8, 10, 14, 15, 16, 17, 19, 20, 21, 24, 27, 28, 29, 30. " 17 "

The following is a summary of the Smithsonian observations for the past two years.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1869	13	13	18	23	14	17	18	15	22	17	9	13	192
1870	19	18	23	21	22	14	20	19	21	21	18	17	233

These observations show a remarkable prevalence of auroras during these two years, and it is anticipated that the number will soon begin gradually to diminish. E. L.

2. *On the Color of the Lake of Geneva and the Mediterranean Sea.*—Mr. Tyndall's experiments with bottles of water from the Lake of Geneva and the Mediterranean sea placed in the convergent beam of an electric lamp seem to prove that the deep blue color is due to the effect of minute foreign particles suspended in the water, intercepting and scattering in excess the shorter waves of light. The path of the beam through the liquid was marked by a blue band.

From the blueness of the light transmitted through a column of the water, he concludes that part of the color must be due to a true molecular absorption of the less refrangible elements accompanying the blue.

These results accord with those of M. Soret, and with Mr. Tyndall's investigations into the causes of the blueness of the sky. He suggests that the fine particles suspended in the water of Lake Geneva, at least, are probably from glacial streams.

3. *A new Manual of Logarithms to seven places of decimals;* edited by Dr. BRUHNS, Director of the Observatory, and Professor of Astronomy at Leipzig. 8vo. B. Tauchnitz, Leipzig, 1870; (D. Van Nostrand, N. Y.)—The arrangement of these tables is in many respects similar to that of Bremiker's excellent edition of Vega's seven-figure logarithms. The type is larger and clearer than that of Bremiker, being of the same Old English form. We agree with the editor in preferring it to the Egyptian type of Schrön, the only serious objection which we should urge to it being the liability to call 6 or 9 by mistake a zero. For the first six degrees of the octant the sines, cosines, tangents and cotangents are given to every second, whereas in Bremiker only sines and tangents are given, and that only for five degrees. For the remaining 39 degrees they are given to every 10 seconds. Wherever space allows, the proportional parts of differences are inserted in the margins of the parts. The arrangement of the pages in these 39 degrees is like that of Bremiker except in putting sines and cosines in *adjoining* columns. The arrangement for the first six degrees is quite different from and is better than that of Bremiker. Extraordinary care, it is claimed, has been taken to secure accuracy in printing, and the logarithms of the circular functions were independently computed, as well as compared with established tables. H. A. N.

4. *Valuation Tables on the "Combined Experience" or "Actuaries" Rate of Mortality;* by ELIZUR WRIGHT. Second edition, revised and enlarged. Folios, xi, and 203 pp. Boston, 1871.—In the practical application of the principles of Life Insurance this country is believed to be in advance of Europe, and for this we are not a little indebted, directly and indirectly, to the State valuation of policies first carried into effect in Massachusetts by Prof. Wright as State Commissioner. These tables are at 3 and 4 per cent interest. The latter are those used in the State valuation.

The few pages of introduction are only enough to make us wish that Prof. Wright would develop at length the mathematical theory of Life Insurance so far as it applies to the methods now employed by American companies. H. A. N.

5. *"The Pliocene Skull," Illustrated.* 8 pp. Washington, D. C. —Bret Harte's "Pliocene Skull," a humorous poetical version of the discovery of the fossil skull in Calaveras Co., California, identifying it as that of the "old Pike" (i. e., from Pike Co., Mo.), Joe Bowers, famous in gold hunters' song, has been very cleverly illustrated by Dr. E. M. Schaeffer, son of Prof. G. C. Schaeffer, of Washington. The sketches add much to the point and wit of the verses.

CHARLES MAYER WETHERILL, Professor of Chemistry in Lehigh University, South Bethlehem, Pennsylvania, died suddenly of heart disease on the 5th of March, aged forty-seven years.

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[THIRD SERIES.]

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ART. XLVI.—*On the Solar Corona*; by Prof. C. A. YOUNG, of Dartmouth College.

ALTHOUGH we have not yet official reports from the different parties who observed the solar eclipse of last December, it is perhaps not necessary to wait for them in order to form an idea of the state in which the problem of the sun's corona now stands.

From what has already appeared in the scientific and news journals, it is clear that while little new matter has been added to the stock of scientific knowledge, and while some questions are left in a more puzzling condition than ever, yet certain of the conclusions arrived at in 1869, but received with a good deal of reserve in certain quarters, have been fully confirmed and placed beyond further reasonable doubt.

The polariscopic observations are less accordant and conclusive than might be wished; undoubtedly because at all the stations they were more or less interfered with and complicated by the presence of clouds or haze.

On the whole, however, they seem to show pretty definitely that a portion of the coronal light is polarized in radial planes, and is therefore derived, not self-originated—almost certainly simple reflected sunlight—though, of course, the polariscope does not inform us whether the reflecting particles are near the sun, or the moon, or in our own atmosphere.

Very perplexing also is the fact that the faint continuous spectrum, which must be in part produced by this polarized component of the corona's light, shows no discoverable traces of the dark lines of the ordinary sunlight-spectrum. Probably they exist but are in some way masked so that they are not easily detected.

But if we grant that the polariscope has demonstrated the derivative character of one fraction of the coronal radiance, it is far more certain that the spectroscope has proved some of the matter of the corona, if not all, to be self-luminous; for its spectrum is characterized by a *bright line.* This line both in 1869 and 1870 was identified with a bright line of the chromosphere-spectrum which coincides exactly with a dark Fraunhofer line at 1474 of Kirchhoff's scale—(wave length 5316 according to Angström). Perhaps I may be allowed to step a little out of my way to add, that while it is customary to speak of this line simply as "a bright line near E," as if its exact position were somewhat doubtful, there is no occasion for the slightest reserve in the matter. The coincidence of the bright C line of the protuberance-spectrum with the dark C is no more accurately ascertained.

In the eclipse of last December, just before the beginning of the totality, the cross wires of my spectroscope were set carefully upon this line, already plainly bright in the spectrum of the chromosphere; and as soon as the sun was covered, I traced it out into the corona more than 16′ from the sun's limb. With the full dispersive power of 13 prisms, I have never been able to find the least want of correspondence between this line as seen in the chromosphere and its dark analogue, except occasionally such as was evidently due to the motion of the luminous matter, producing slight changes of refrangibility, sometimes in one direction and sometimes in the other.

So far as I can learn, this line was verified last December by all the spectroscopic observers who saw anything at all, with the single exception of Lieut. Brown of Lord Lindsay's party.

Two other faint lines which I saw in 1869 between this and D, and doubtfully* reported as corona-lines (see this Journal for Nov. 1869, p. 376), were not seen by any one on this occasion, unless perhaps one of them by Father Denza in Sicily.

In a letter from Father Secchi which appeared in the Astronomische Nachrichten for Feb. 21, 1871, he writes, "*Mon collegue le P. P. Denza directeur de l'observatoire de Moncalieri, observa avec un spectroscope, que j'avais convenablement disposé*, deux *raies brillantes dans le couronne, une prés de l'E de* Fraunhofer, *l'autre au milieu entre le vert et le jaune.*" Very possibly this latter ray "half way between the yellow and the green" may be one of the two.

Considered as a demonstration of self-luminosity, however, *one* bright line is just as conclusive as many.

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* I have experienced some annoyance during the past year at seeing these lines in several publications put upon the same footing as 1474. I was never at all confident as to their coronal character.

Nor can there be any doubt as to the location of the self-luminous matter. It cannot be in our own atmosphere, for no possible reason can be assigned why the particular molecules of air, that happen to lie near the lines which join the eye of the observer with the edge of the moon, should become luminous rather than others in a different portion of the sky.

Nor can it be at the moon; otherwise of course it would always be visible around her disc, since there is nothing in the mere accident of her being on the line of syzygies which could account for the phenomenon. I may add in passing, that I have often and carefully examined the neighborhood of the moon's limb, half hoping that some possible rare atmosphere of our satellite might reveal itself at some time by a faint auroral spectrum; thus far, however, without success.

Accordingly it is now universally, I think I may say, acknowledged that *one important element of the corona consists in a solar envelope of glowing gas, reaching to a considerable elevation.* Mr. Lockyer, who is still disposed to assign to the solar element of the corona a lower relative importance than most other astromomers, concedes a thickness of from *six* to *ten* minutes. (See an article by him in Nature for Feb. 23d.)

For this envelope the name of "*leucosphere*" has been proposed by a member of the Royal Astronomical Society at one of its recent meetings, and it seems to be a very suitable term and well worthy of adoption. It has been objected to on the ground that "*chromosphere*" covers the whole bright-line region around the sun; but when the latter name was first proposed, there was evidently no idea that above the envelope of hydrogen there lay another from 20 to 100 times as extensive, and it would certainly be very convenient to restrict it to the lower red hydrogen stratum of the solar atmosphere, and retain the new term to designate this more elevated mass of gaseous matter.

How extensive then is this leucosphere? Perhaps the question can hardly be answered definitely as yet; but it seems likely that it will be found to be at least from 8′ to 10′ thick on the average, with occasional prolongations of double that extent; not impossibly it may turn out to have no upper limit whatever, but to extend outward indefinitely into space.

Were it not for the interference of our atmosphere, the matter could be settled very summarily, at least as to a minor limit, by the record of the spectroscopic observations. Prof. Winlock observed the green line at a distance of more than 20′ from the sun, and others nearly as far. But there can be no doubt that had the spectroscope, during the eclipse, been directed upon any reflecting surface illuminated by the corona light, the same green line would have appeared in its spectrum. The question, of course, at once arises, whether the presence of this line at such a distance from the sun was not due to atmospheric reflection, especially as the sky was full of haze and light cirrus clouds at all, or nearly all, the stations of observation.

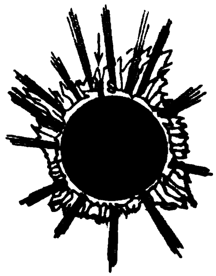
It is certainly difficult to say that such might not have been the case to some extent, for the hydrogen lines were seen at an elevation of 4′ to 5′, far above any possible hydrogen, and faintly even on the disc of the moon itself—evidently by just such an atmospheric reflection.

There is, however, an important difference between the behavior of the hydrogen lines, and that of 1474. At the edge of the chromosphere there was a sudden and very great falling off in the brightness of the former, while no such boundary was observed for the latter; the line grew regularly and continuously more faint as the distance from the sun increased, until it simply faded out, no abrupt alteration of its brilliancy being anywhere noticed. (I now speak of my own observations; but so far as I have learned, the experience of others was the same.)

In 1869 the difference between the hydrogen lines and 1474 was still more marked. The former could hardly be traced at all beyond the actual limit of the chromosphere, the air being so clear that there was very little atmospheric effect.

. But there is another way of approaching the subject. The spectroscopes used by our party at Jerez were of two different classes, and by a combination of their results we may obtain an indication of considerable value.

In the instruments employed by Prof. Winlock and myself, and I presume by the greater number of the eclipse observers, the spectroscope is attached to the eye-end of a telescope whose object-glass throws upon the slit a distinct image of the body to be examined. Such an instrument may be called an *analyzing* spectroscope, since it deals with elementary portions of the luminous area under investigation. Thus, if the figure represent the image of the corona, chromosphere and moon formed by the object-glass of the telescope, then if the slit be placed as at S, the spectrum seen will be produced solely by light from those elements of the luminous area whose foci fall within its jaws. The spectrum will be divided longitudinally into two portions, of which the one derived from the upper portion of S will show only the lines due to the leucosphere, while the other will exhibit the chromosphere lines *plus* those of the leucosphere.



(Of course it must be remembered that while the hydrogen does not extend above the limit of the chromosphere, the coronal matter does reach down to the surface of the sun, and in the chromosphere is mingled with the hydrogen; indeed, except during eclipses, it is only at the very base of the chromosphere that the 1474 line can be seen reversed with our present spectroscopes.)

If now we assume the chromosphere and leucosphere each to be of uniform brightness throughout (a supposition not strictly true but allowable for our present purpose), then by putting a for the angular area of the chromosphere, x for that of the leucosphere, i for the intensity of the bright 1474 line as seen in an "analyzing" spectroscope, and ni for the intensity of the bright C line observed with the same instrument, we shall have

$$i x = [1474],$$

where [1474] represents the total quantity of "1474 light" coming from the whole leucosphere. Similarly

$n. i. a. = [C]$, where [C] represents in the same manner the total "C light" from the chromosphere.

$$\text{Hence} \quad x = n. a. \frac{[1474]}{[C]}$$

Now, as nearly as I can estimate, the ratio between the brightness of the C and 1474 lines is about the same as that between a star of the first magnitude and one of the fifth or sixth. That is to say, the C line is between twenty-five and one hundred times as bright as 1474; so that in our equations we may write $n=50$ as a fair approximation, and we shall have

$$x = 50\, a \frac{[1474]}{[C]}$$

In order to find x in terms of a it only remains to find the ratio of [1474] to [C]. For this purpose we must employ a spectroscope so arranged that its slit may receive at every point, light coming indiscriminately from every part of the object. This is the case when a spectroscope is used, unconnected with any telescope, by simply pointing the slit of its collimator toward the source of light. Thus used it may be called an *integrating* instrument, since it sums up in each bright line of its spectrum, the whole quantity of each kind of light reaching the slit from the whole luminous area included within its field.

An instrument of this sort was employed by Prof. Pickering in 1869, and with results of considerable importance.

Accordingly, two of the gentlemen of our party were equipped in the same manner, and one of them, Mr. Pye, by my request, noted the brightness of the lines on an arbitrary scale from ten down, with the following result: [C] 8·5, [D^3] 5·5, [1474] 10, and [F] 3. Probably the squares of these numbers would more nearly express the true ratio of the intensities, since we seem instinctively to estimate one light as twice the intensity of another when it appears of the same brightness at a double distance, and so on.

If so, we have $\frac{[1474]}{[C]} = \left(\frac{10}{8\cdot5}\right)^2 = \frac{100}{72}$ nearly; and recurring to our last written equation we get $x=69\cdot4\,a$.

Similarly, from D_3, $(n=20)$, I find $x=64\cdot5a$; and from F, $(n=10)$ $x=111\cdot1a$.

The last value is evidently too large, the discrepancy probably arising from the fact that Mr. Pye's instrument having a prism of the extra dense and very yellow flint-glass considerably reduced the intensity of the F line by absorption.

Thus far, we have neglected the inequalities of shading and illumination; but as both chromosphere and leucosphere decrease in brilliancy pretty regularly from the limb of the sun, and since the upper limit of the former is much the more definite, it is evident that the introduction of these considerations would increase the computed ratio. We may, I think, then safely assume that the angular area of the leucosphere is *at least* 70 times as great as the area of that portion of the chromosphere and prominences which was exposed to view during the totality. I fear it is not possible to estimate this area with much certainty, but think it could hardly have been equivalent to anything less than a ring of 9″ or 10″ wide surrounding the sun. If so, we find the leucosphere to be equivalent to a ring of about 10′ in width, and considering the irregularity of its outline, some of the angular prolongations would be likely to attain twice that distance.

I am, of course, aware that the numerical data of this calculation are very uncertain, being mere estimates, not measurements; but the principle is correct, and the results are not sensibly affected by any ordinary amount of atmospheric influence, since the different colored rays would not have the *ratio* of their brilliancies much disturbed under any reasonably fair conditions.

The result agrees very well also with the photographs, drawings, and estimates of skilled observers.

As for the *long rays*, both bright and dark, which are often, and perhaps usually, seen crossing the leucosphere and reaching far beyond, the question whether they are also solar appendages appears to be very different and far more doubtful.

In the first place, I doubt if they are *always* present. At any rate, in 1869, in a most exceptionally clear atmosphere, I saw nothing of them at Burlington, Iowa, and believe (but am not absolutely certain) that none of our party did; while some observers in Kentucky saw them well, and at Sioux City they were especially conspicuous, as is evident from the remarkable, and I have no doubt, accurate picture given by Mr. Gilman in the Eclipse Report of the Naval Observatory.

In December, so far as I have heard, every one saw them. I have no hesitation in affirming that the corona as it appeared to me then was a very different phenomenon from what I saw the year before, and far more complex.*

The photographs also taken by Lord Lindsay's and the American parties in Spain, appear to differ essentially from each other, and from those taken by Mr. Brothers, in Sicily; and that in such a way as to suggest at least, that this more extensive radiance is of a far less permanent character than the leucosphere, and possibly of a different origin.

Should it turn out to be visible only where the sky is hazy, it might then be regarded as an effect of our own atmosphere produced, of course, not by the ordinary photospheric sunlight (which, as has been abundantly shown, by many writers, cannot during totality, illuminate the air near the moon's place), but by the light from the prominences and the lower regions of the leucosphere.

If, on the contrary, as seems to be the case, this radiance is often seen under unexceptionable atmospheric conditions, we appear to be shut up to one of two theories; either on the one hand that of Prof. Norton and Mr. Proctor, whose views regarding these rays are nearly identical, and represent them to be streams of matter, similar to cometary substance or auroral† beams, driven off by some solar repulsion; or on the other hand that of Oudemans, who considers them to be purely optical effects produced in cosmical dust between us and the moon, by the sunlight streaming across the uneven and ragged edge of our satellite.

With reference to the former theory, it is probably sufficient to refer to Mr. Proctor's recent work on the sun, and to a paper which Professor Norton has published in a late number of this Journal, wherein his views are fully explained. According to this view, the leucosphere and the rays are alike solar appendages, and of identical origin and material.

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* Mr. Lockyer, in "Nature" for Feb. 23d, quotes from a letter of mine written a year ago, to show that my opinions regarding the nature of the corona have been considerably modified since then; and this is true to some extent, though I think the present approximation of our views is owing quite as much to a change in his own ideas—as would be evident on referring to his papers of the same, and even somewhat later date. But I should *still* write "I am strongly disposed to believe that the whole phenomenon" (*i. e., the Corona as I saw it in* 1869) "is purely solar."

† Since my name has sometimes been referred to in connection with the so-called "Auroral Theory of the Corona," it is proper for me to state, that I make no claim to be its originator.

When I discovered (as I supposed), the identity of the bright line in the corona spectrum with a line in that of the aurora, and announced my belief in the substantial identity of the two phenomena, I considered myself as simply subscribing to a view already current, and bringing a new argument to its support.

So far as I know, Prof. Norton was the first to work out and publish a connected theory of the subject, basing his conclusions largely upon his discussions of Donati's comet, which were printed in this Journal some years ago. Prof. Winlock also informs me that he has held and published a very similar opinion, and so I think have more than one of the European astronomers, though I cannot now give references. My own father, more than twenty years ago, was accustomed to teach from the same chair of astronomy which I now occupy, an essentially similar doctrine. Thus the idea had long been familiar to me, and I presume more or less so to astronomers generally.

The theory of Oudemans is stated in a letter to "Nature," contained in the number for Nov. 10, 1870.

With good weather, it would seem possible to decide between these two hypotheses at the next eclipse.

A series of corona photographs taken as rapidly as possible on the plan pursued by Mr. Brothers (who has shown that an exposure of from 8 to 10 seconds is sufficient to produce a fine picture) would probably indicate whether the dark streaks are really related to mountains on the edge of the moon or not.

It is probable also, as Prof. Pickering has suggested, that important information may be obtained by observing them with a spectroscope of high dispersive power and widely opened slit, using the 1474 line just as the C line is used in examining the prominences.

The telescope, to which the spectroscope employed for the purpose is attached, should be of wide angular aperture, so as to give abundant light, but of very short focus, forming an image of the sun not much more than $\frac{1}{4}$ of an inch in diameter, in order that the rays may be so little magnified that their outline, if they are really of leucospheric origin and give the green monochromatic light, may be readily observed through the slit.

There remains still unsettled another interesting series of questions concerning the nature of the substance composing the leucosphere, and the relation of this envelope to the sun; whether it be a true atmosphere, or a mere cloud of transient particles—a meteor-flock, as Mr. Proctor imagines.

Apart from the difficulty of supposing such a multitudinous and continual supply of meteoric matter as this theory would require, and neglecting all consideration of the peculiar form assumed by this envelope, which seems to be deepest precisely over those solar latitudes where the spots and prominences are most numerous, and even to be governed in the minutiæ of its outline by the position of its prominences, I find what seems to me an almost insuperable objection to it in the powerful winds and cyclones which prevail in the region above the chromosphere at elevations of from 50,000 to 100,000 miles.

These winds, by which the tops of the solar flames are whirled and driven, present, so far as observations now go, every characteristic of true aerial currents in a continuous medium; and the whole appearance and behavior of the solar protuberances, except at the moment of eruption, is that of clouds floating in an air.

But if we then consider the leucosphere as a true solar atmosphere, how can we reconcile its enormous extent with the known smallness of the pressure at its base, determined by the experiments of Lockyer, Frankland, and Wullner? In either of two ways; first, and perhaps on the whole most probably, this atmosphere may consist of some new kind of matter whose density is far below that of even hydrogen; or it may be composed of matter whose specific *gravity* (*not density*) is diminished, annihilated, or even rendered negative by some such solar repulsion as appears to be operative in the formation of a comet's tail.

There is no doubt that the line which characterizes its spectrum coincides with one of the lines of the *Iron* spectrum within the limits of any present means of observation: and so close a coincidence can hardly be accidental. And yet in the spectrum of iron, this line is only a faint and unimportant one—one of the last to make its appearance under the stimulus of the electric spark, and so little comparable in intensity with many others in its immediate neighborhood, that Mr. Huggins failed to map it on his spectral chart.

It is certainly difficult to understand how, if this line be really of the same origin as its fellows, it should remain the sole survivor of changes which have been able to exterminate from the spectrum all its more conspicuous associates; and accordingly, from this point of view, it becomes natural to suppose, as I suggested in 1869, that when the line appears in the spectrum of iron it may be due not to the iron itself, but to some associated substance (possibly standing in relation to the peculiar magnetic properties of this remarkable metal)—some occluded gas, which can also exist free in a state of inconceivable tenuity, as we have it in the leucosphere, and probably also in the streamers of the aurora, and in the tails of comets*—a near relative, so far as gravity is concerned, to the luminiferous ether and to the Urstoff of German speculators.

The view of Mr. Lockyer agrees with this in supposing the leucosphere to consist of some new form of matter.

On the other hand, it is to be noted that alterations of pressure and temperature do produce in known spectra great changes, somewhat such as would be required in order to reduce the complicated spectrum of iron to this one line. (But I do not know of any case where one of the unimportant lines is the last to disappear.)

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* It is perhaps worthy of remark that in the spectrum of Brorsen's comet, as given by Mr. Huggins, the position of one of its three bands appears to coincide with 1474, so far as can be judged from the figure and the measurements, which, however, do not permit any very rigid testing of the matter. It seems somewhat probable that this same line will be observed in the spectrum of the tail of the first bright comet offered to observation.

Furthermore, those other lines of iron, which are often seen in the chromosphere spectrum, are nearly all of about the same order of prominence as 1474. The more conspicuous iron lines seldom if ever appear reversed, while in the case of other substances their strongest spectral lines are always the first to turn bright.

If then we admit a sufficient repulsive force, it seems still possible to suppose that the leucosphere may consist of iron in the state of vapor and fog; and the well known wide diffusion of this metal in meteoric matter makes it comprehensible how its lines should occur in the spectrum of our own terrestrial aurora, and in any other places where they may be found.

Possibly future researches in the laboratory may throw clearer light upon the subject.

It is hardly necessary to add that our own terrestrial atmosphere, *when clear*, appears to me to play only a very subordinate part in the phenomenon. Some influence it must, of course, have; but remembering how much the inner portion of the coronal ring exceeds in brilliance the outer, it would seem that the illumination of the lunar disc must give us an exaggerated measure of the true atmospheric effect. This illumination makes the edge of the moon only enough brighter than the center to give it the appearance of a globe, but of almost inky blackness.

With the subjective element, the case is very different. In untrained observers especially, it may be so influential that two intelligent persons standing side by side will describe and even sketch upon paper appearances most grotesquely different from each other and from the truth.

Even skilled observers are greatly affected by the strangeness and peculiar nature of the phenomenon, and the excitement of the occasion.

Hanover, March 23d, 1871.

ART. XLVII.—*On the supposed Legs of the Trilobite, Asaphus platycephalus;* by JAMES D. DANA.

AT the request of Mr. E. Billings of Montreal, I have recently examined the specimen of *Asaphus platycephalus* belonging to the Canadian Geological Museum, which has been supposed to show remains of legs. Mr. Billings, while he has suspected the organs to be legs so far as to publish on the subject,[*] has done so with reserve, saying, in his paper, "that the first and all-important point to be decided, is whether or not the forms exhibited on its under side, were truly what they appeared to be, locomotive organs." On account of his doubts, the specimen was submitted by him during the past year to the Geological Society of London; and for the same reason, notwithstanding the corroboration there received, he offered to place the specimen in my hands for examination and report.

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[*] Q. J. Geol. Soc., No. 104, p. 479, 1870, with a plate giving a full-sized view of the under surface of the trilobite, a species that was over four inches in length.

Besides giving the specimen an examination myself, I have submitted it also to Mr. A. E. Verrill, Prof. of Zoology in Yale College, who is well versed in the invertebrates, and to Mr. S. I. Smith, assistant in the same department, and excellent in crustaceology and entomology. We have separately and together considered the character of the specimen, and while we have reached the same conclusion, we are to be regarded as independent judges. Our opinion has been submitted to Mr. Billings, and by his request it is here published.

The conclusion to which we have come is that the organs are not legs, but the semi-calcified arches in the membrane of the ventral surface to which the foliaceous appendages, or legs, were attached. Just such arches exist in the ventral surface of the abdomen of the Macrura, and to them the abdominal appendages are articulated.

This conclusion is sustained by the observation that in one part of the venter three consecutive parallel arches are distinctly connected by the intervening outer membrane of the venter, showing that the arches were plainly *in the membrane*, as only a calcified portion of it, and were not members moving free above it. This being the fact, it seems to set at rest the question as to the legs. We would add, however, that there is good reason for believing the supposed legs to have been such arches in their continuing of nearly uniform width almost or quite to the lateral margin of the animal; and in the additional fact, that, although curving forward in their course toward the margin, the successive arches are about equidistant or parallel, a regularity of position not to be looked for in free-moving legs. The curve in these arches, although it implies a forward ventral extension on either side of the leg-bearing segments of the body, does not appear to afford any good reason for doubting the above conclusion. It is probable that the two prominences on each arch nearest the median line of the body, which are rather marked, were points of muscular attachment for the foliaceous appendage it supported.

With the exception of these arches, the under surface of the venter must have been delicately membranous, like that of the abdomen of a lobster or other macruran. Unless the under surface were in the main fleshy, trilobites could not have rolled into a ball; and the fact that this particular species of Asaphus is not found so rolled may be owing to the unusual size or firmness, and also the position, of these slender arches.

ART. XLVIII.—*Description of some new Fossil Serpents, from the Tertiary Deposits of Wyoming;* by Professor O. C. MARSH, of Yale College.

AMONG the Reptilian fossils discovered by the Yale College party, during their explorations last summer in the Green River Tertiary basin, west of the Rocky Mountains, were the remains of several species of Serpents, which are of peculiar interest, as they are the first extinct Ophidians found in the interior of the continent, and, with the exception of three species from the Eocene marl of New Jersey,* the only fossil representatives of this order yet detected in this country.

These remains, which are now in the Peabody Museum of Yale College, consist mainly of vertebræ, of various sizes, many of them more or less injured, but in general with the most characteristic parts well preserved. Nearly all the specimens obtained evidently belonged to constricting serpents, closely related to the modern Boas of South America, although considerably smaller, and generically distinct. A few of the specimens indicate snakes of moderate size, with apparently quite different affinities.

In comparing the larger series of these fossil vertebræ, especially those from near the middle of the trunk, with the corresponding vertebræ of the living species of *Boa*, a strong resemblance will be noticed in the more important characters, especially in the transversely elliptical outline of the articular cup and ball; in the obtuse lateral elevation extending from the diapophyses to the articular ball; and in the elongated median ridge on the inferior surface of the centrum. The differences between them, however, are important, and indicate clearly that the fossil specimens represent a separate genus, for which the name *Boavus* † is proposed, in allusion to the not improbable relationship of the two types. In the extinct genus, the articular ball and cup are more nearly vertical, and their outline forms a more full transverse ellipse. The neural arch is proportionally more elevated, and has on either side a low ridge, extending backward from the articular face of the zygosphene, and expanding over the zygantral cavities. The latter are more deeply excavated than in *Boa*. The neural spine is shorter, its antero-posterior extent, in the specimens in which it is preserved, being greater than its height. The diapophyses are convex throughout, while those of *Boa* are more or less concave on the lower part of their articular face. The lateral elevation, extending from the diapophyses to the articular ball, is, in *Boavus*, situated lower on the centrum, and is less rounded. The hypapophysial ridge, also, is sharper, and extends nearer to the inferior edge of the articular ball.

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* This Journal, vol. xlviii, p. 397, Nov. 1869.

† *Boa*, and *avus*, grandfather.

From the vertebræ of *Dinophis* Marsh, which genus includes the only fossil Ophidians hitherto found in this country, as well as from those of the nearly allied *Palæophis* of Owen, the specimens of *Boavus* here described are widely separated, especially by their greatly inferior size; by the shorter neural spine; by the broader zygosphene, which exceeds in transverse diameter the articular cup, as in most modern serpents; by the elevation extending backward from the zygosphene; by the more expanded diapophyses; and by the well developed lateral and inferior median ridges on the centrum. The vertebræ of *Boavus*, however, resemble those of *Palæophis* and *Dinophis*, and differ from those of *Boa*, *Crotalus*, and many other modern serpents, in having the sides of the neural canal extended forward nearly to the edge of the articular cup.

Boavus occidentalis, sp. nov.

This species is established on eight vertebræ, nearly all from the middle dorsal region. They evidently represent several individuals, as they differ considerably in size, and were found at three separate localities. They indicate constricting serpents between six and eight feet in length. The neural arch in this species is elevated and massive. The neural spine is short, and triangular at its base, which rests on the posterior three-fourths of the arch. The zygosphene is convex above, slightly excavated in front, and without a median tubercle. The neural canal has a distinct median epapophysis on its floor, and sharp lateral ridges, which give it a sub-trifoliate outline. The diapophyses are auriform, and project below the inferior margin of the cup. The hypapophysis is a sharp ridge, beginning at the margin of the cup, and ending, just before reaching the ball, in an obtuse projection.

The principal dimensions of one of the largest vertebræ of this species are as follows:—

Length of centrum from edge of cup to convexity of ball,	4·50	lines.
Transverse diameter of cup,	2·80	"
Vertical diameter of cup,	2·50	"
Transverse diameter of zygosphene at base,	3·50	"
Distance from top of zygosphene to lower margin of cup,	5·	"
Vertical diameter of ball,	2·45	"
Width of neural canal in front,	1·75	"
Height of neural canal in front,	1·10	"

The various specimens representing this species were found in September last by H. B. Sargent, A. H. Ewing, and the writer, at Grizzly Buttes, near Fort Bridger, Wyoming Territory. The geological horizon is probably Eocene.*

Boavus agilis, sp. nov.

This species, which was nearly the same in length as the preceding, although apparently much more slender, is indicated by five vertebræ, all from the dorsal region, and representing two or more individuals. They may readily be distinguished from the corresponding vertebræ of *B. occidentalis*, by the proportionally more elongated centrum; by the rounder and more inclined cup; by the more expanded anterior zygapophyses; by the diapophyses, which do not extend below the inferior surface of the centrum; and by the hypapophysial ridge, which is more obtuse, and in its anterior portion expands rapidly until it disappears in the margin of the cup.

The largest vertebra of this series has the following dimensions:—

Length of centrum from edge of cup to convexity of ball,	4·25	lines.
Transverse diameter of cup,	2·50	"
Vertical diameter of cup,	2·40	"
Vertical diameter of ball,	2·35	"
Width of neural canal in front,	1·75	"

The specimens on which this species is based were discovered by the writer, near Fort Bridger, in the same formation as the remains above described.

Boavus brevis, sp. nov.

The serpents representing this species were considerably smaller than those described above, and evidently much shorter in proportion to their bulk, being probably not more than four or five feet in length. The only remains obtained consist of three dorsal vertebræ, all in good preservation, and evidently belonging to two different individuals. These vertebræ have the centrum unusually short, its extent measured on the inferior surface scarcely exceeding the transverse diameter of the zygosphene. The neural arch is low, and bears on its posterior two-thirds the neural spine, which is quite short, and truncated. The zygosphene is less massive than in the preceding species, and has a slight median swelling on the anterior margin of its base.

The dimensions of the most perfect of these vertebræ are as follows:—

Length of centrum from edge of cup to convexity of ball,	2·20	lines.
Transverse diameter of cup,	1·60	"
Vertical diameter of cup,	1·25	"
Transverse diameter of zygosphene at base,	1·85	"
Distance from top of zygosphene to lower margin of cup,	2·80	"
Width of neural canal in front,	1·00	"
Height of neural canal in front,	·90	"

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* This Journal, III, vol. i, p. 192, March, 1871.

The specimens here described were found by H. B. Sargent, in the same fresh-water Tertiary deposits, and near the same locality, as the two preceding species.

Lithophis Sargenti, gen. et sp. nov.

This species and genus are at present represented by three trunk vertebræ, only one of which, however, is sufficiently well preserved to show all its more important characters. The specimens indicate a small serpent about four feet in length, and probably, like the preceding species, allied to the constrictors. From the vertebræ of *Boavus*, as well as from those of the other fossil Ophidians discovered in this country, the present specimens may be readily distinguished by the more compressed centrum, and especially by the articular cup and ball, which are circular in transverse outline, as in the Arican *Eryx*, and stand nearly at right angles to the axis of the centrum. The anterior zygapophyses, also, are more extended outward, and their articular faces have a greater antero-posterior expansion than in any of the described species. The diapophyses have their articular surfaces divided by a horizontal groove, having a rounded tubercle above, and a pointed projection below, as in the modern *Bascanion*. There is no lateral ridge extending from the diapophyses to the articular ball, as in *Boa* and *Boavus*, the converging sides of the centrum being nearly flat. The hypapophysis is reduced to a wedge-shaped ridge, extending the whole length of the centrum, and having its sharp apex below the inferior margin of the cup. The floor of the neural canal has a prominent, obtuse median ridge throughout its whole length, but no lateral ridges are apparent.

The principal measurements of the best preserved vertebra are as follows:

Length of centrum from edge of cup to convexity of ball,	**2·80**	**lines.**
Transverse diameter of cup,	**1·35**	**"**
Vertical diameter of cup,	**1·35**	**"**
Vertical diameter of ball,	**1·30**	**"**
Width of neural canal in front,	**·90**	**"**
Distance from end of anterior zygapophysis to hypapophysis,	**3·00**	**"**
Distance between ends of the anterior zygapophyses,	**4·50**	**"**

For the extinct genus manifestly indicated by the fossils here described, the name *Lithophis** is proposed, and the species they represent may appropriately be called *Lithophis Sargenti*, after the discoverer, Mr. H. B. Sargent, of the Yale Scientific party, who found the specimens in the Eocene "Mauvaises Terres" beds at Grizzly Buttes, near Fort Bridger.

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* Λίθος, *stone*, and 'Οφις, *serpent*.

Limnophis crassus, gen. et sp. nov.

One of the most interesting of the Ophidian fossils obtained during our explorations in Wyoming was a single anterior dorsal vertebra, very well preserved, and quite unlike any hitherto described. It indicates a moderately sized constricting serpent, perhaps six feet in length, but evidently of a very different type from the species already characterized. On comparing it with the corresponding vertebræ of *Boavus* and *Lithophis*, a striking difference is at once seen in the dimensions of the articular cup, which considerably exceeds in width the parallel diameter of the base of the zygosphene, a feature only observed heretofore in a few fossil serpents from the Eocene, and quite unknown in modern species. The cup and ball have a subtriangular, ovate outline, the greatest transverse diameter being above the center: they are also placed nearly at right angles to the axis of the centrum. Another marked peculiarity of this vertebra is the unusual posterior extension of the neurapophyses, which project some distance beyond the articular ball. Their nearly flat sides slope downward and outward like a gable roof, without any indication of the angle so characteristic of the vertebræ of Palæophis,* which in several other respects the present specimen strongly resembles. The neural spine is unfortunately not preserved, but it was evidently short, and confined to the posterior two-thirds of the neural arch. The anterior zygapophyses had only a moderate expansion. The diapophyses have, for the attachment of the rib, a single, rounded, and prominent tubercle, with its lower border above the inferior margin of the cup, and with no indication of a dependant process. There is also no ridge extending from the diapophysis to the articular ball. The hypapophysis consists of a single, compressed, obtuse tubercle, which descends from the middle of the centrum downward and slightly forward; its base occupying rather more than half of the median line.

The more important dimensions of this vertebra are as follows:

Length of centrum from edge of cup to convexity of ball,	3·20	lines.
Transverse diameter of cup,	2·30	"
Vertical diameter of cup,	1·80	"
Vertical diameter of ball,	1·70	"
Distance from posterior summit of neurapophyses to inferior margin of ball,	3·50	"
Length of hypapophsis below inferior margin of cup,	·90	"

This interesting vertebra, although the only one of the kind at present known, is so characteristic, and well preserved, and differs so widely from the corresponding remains of Ophidians hitherto described, as to justify establishing for its reception a new genus, which may be called *Limnophis.*[*] The species may properly be named *Limnophis crassus*, in reference to the probable proportions of the extinct serpent thus indicated. The specimen was discovered by Mr. A. H. Ewing, a member of the Yale party, in the Eocene fresh-water deposits, near Marsh's Fork, about fifteen miles from Fort Bridger, in Wyoming.

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* Memoirs of Paleontological Society of London, 1850, p 57.

Yale College, New Haven, March 20th, 1871.

Art. XLIX.—*Contributions to Chemistry from the Laboratory of the Lawrence Scientific School. No. 14.—On the Estimation of Phosphoric Acid;* by Charles E. Munroe.

§ 1. Though the methods commonly in use for the quantitative determination of phosphoric acid are capable in most cases of giving accurate results, yet it will, I think, hardly be claimed for them, that they render new methods unnecessary, and I have therefore undertaken the following investigation in the hope of adding something of value to our analytical resources.

My attention was first called to the employment of ferric chloride with the addition of sufficient mercuric oxide to neutralize the excess of acid. Free mercuric oxide was first added directly, but, as a complete separation could not be effected in this manner, it was found more advantageous to produce the oxide in the solution itself. This was accomplished by first adding mercuric chloride and then potassic or sodic hydrate. As sodic hydrate[†] can be obtained in commerce absolutely pure this was employed. The precipitate, consisting of ferric phosphate and ferric and mercuric oxides was then evaporated to dryness in the manner recommended by Chatard,[‡] filtered and washed on the Bunsen pump.[§] Unhappily the phosphoric acid redissolved after evaporation to dryness and the process was therefore abandoned. Bunsen's delicate test with magnesium wire was used throughout the work, sometimes in connection with ammonic molybdate, for the detection of phosphoric acid.

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[*] *Λίμνη, lake*, and Ὄφις, *serpent.*

[†] The article used was manufactured in England by the direct oxidation of metallic sodium.

[‡] This Journal, vol. iv, p. 247.

[§] A simple modification of the Bunsen pump may be obtained by connecting a piece of glass tubing, by means of rubber, with a Bunsen funnel. A funnel holding 50 $c.m.^3$ connected with a piece of glass tubing one meter in length emptied itself five times while another funnel of the same capacity, arranged as usual, did so but once. The pressure was so great that the filter had to be protected with a platinum point to prevent it from giving way.

I next studied the behavior of aluminic oxide toward phosphoric acid, and this time met with better success.

The following course was pursued. To the boiling phosphate solution a weighed quantity of pure aluminic sulphate, previously dissolved, was added. A solution of mercuric chloride was then added, and finally sodic hydrate until a precipitate of mercuric oxide was obtained which remained undissolved. In order to hasten the operation the precipitate was allowed to settle and the supernatant liquid poured upon the filter. The gelatinous precipitate was then evaporated to complete dryness as before mentioned, filtered, ignited and weighed. The increase of weight, over that of the aluminic oxide used, was phosphoric oxide. It was found extremely difficult to burn the filter. Care must be taken that for every gram of phosphoric oxide at least two grams of aluminic oxide are added.

The percentage of aluminic oxide, in the sulphate used, was determined by ignition, ammonic carbonate being used to drive off the last traces of sulphuric oxide. The following results were obtained:

(1) ·7320 grms. $Al_2(SO_4)_3 . 18H_2O$ gave ·1310 grms. Al_2O_3 = 17·89 p. c.
(2) ·7100 " " " ·1270 " " = 17·87 "
Mean 17·88.

Anhydrous disodic phosphate was the first salt treated. In order to work with greater rapidity a solution of known strength was prepared of which 50 c.m.₃ corresponded to ·6195 grms. of phosphate. This gave the following results:

(1) ·6195 grms. gave ·3099 grms. P_2O_5 = 50·02 p. c.
(2) ·6195 " " ·3100 " " = 50·03 "
(3) ·6195 " " ·3097 " " = 50·01 "
(4) ·6195 " " ·3097 " " = 50·01 "
Mean 50·02. Theory 50·00.

Ammonio-sodic phosphate ($Na(NH_4)H Po_4, 4H_2O$) was next analyzed. The amount of phosphoric oxide in the salt was found by igniting it and weighing the sodic metaphosphate.

(1) 1·4650 grms. gave ·6172 grms. $NaPO_3$ = 29·32 p. c. P_2O_5
(2) 1·5017 " " ·6344 " " = 29·40 " "
Mean 29·36.

By the alumina process the following results were then obtained.

(1) 1·5405 grms. gave ·4514 grms. P_2O_5 = 29·30 p. c.
(2) 1·2610 " " ·3707 " " = 29·39 "
(3) 1·1355 " " ·3321 " " = 29·29 "
Mean 29·33.

Calcic phosphate did not give good results by this process on account of the difficulty of washing out the calcic sulphate formed. I succeeded no better with ammonio-magnesic phosphate doubtless because some of the magnesia went down with the alumina. These experiments are sufficient to show that phosphoric acid may be determined with extreme precision in the alkaline phosphates by the method above given, but the method applies with advantage only to these salts. On the other hand it must be remembered that many phosphates may be decomposed by fusion with the alkaline carbonates and the phosphoric acid then determined as above, so that in fact the method applies in perhaps the greater number of cases which occur in practice.

§ 2. Rose's* method for the separation of phosphoric acid by means of mercurous nitrate and subsequent estimation in the form of pyrophosphate of magnesia has been much used. It will, however, be acknowledged that it has some serious defects. It is tedious, the many operations required increase the chances of error, and the fusion of mercurous phosphate with the mixed carbonates exerts, according to Rose, a sensible action upon the platinum crucible. Nevertheless the perfect separation which it gives is a strong recommendation of the method.

It appeared possible that a valuable modification of this process might result from the addition of mercuric oxide in the manner already employed in the alumina process above described.

The experiments were executed in the following manner. To a boiling solution of the phosphate mercurous nitrate was added in slight excess. This threw down a lemon-yellow colored, crystalline precipitate of nitro-mercurous phosphate which adhered to the sides of the beaker when touched by the stirring rod. Mercuric nitrate was then added and finally sodic hydrate until a slight precipitate of mercuric oxide was obtained which remained undissolved. The mixture of the two salts was found to be insoluble in both hot and cold water, and to wash like sand.

The next step was to find a readier means of treating the nitro-mercurous phosphate.

It was first proposed to dissolve the washed and dried precipitate in chlorhydric acid and titrate with potassic permanganate so as to oxidize the mercurous to the mercuric salt. This process failed. The salt was then treated with sulphuric acid. The final reaction was perfectly sharp, but the results were not satisfactory.

These results having proved that nothing was to be gained in that direction, I tried to remove the mercury by decomposing the nitro-mercurous phosphate with nitric acid and precipitating the mercury with sulphydric acid or ammonic sulphide. The phosphoric acid was then to be determined in the filtrate by the ammonio-magnesian solution. On examining the mercurous sulphide it was found that some of the phosphoric acid was always precipitated with it. Its presence was proved by Bunsen's test with the magnesium wire. The salt was then dissolved in a solution of potassic cyanide and a current of sulphydric acid passed through, but with the same result as before. Again it was thought that the phosphoric acid might be precipitated directly from the cyanide solution by ammonio-magnesic chloride, but experiment showed that the cyanide contained so much cyanate and carbonate that, although the solution was boiled and chlorhydric acid was added to it, accurate results could not be obtained.

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* Traité de Chimie Analytique, ii, 708.

As the ignition of the nitro-mercurous phosphate with the non-volatile metallic oxides, in order to drive off the mercury, promised well, this process was then tried in the following manner.

The dried salt was thoroughly mixed with a weighed quantity of cupric oxide in a platinum crucible and the filter placed on top. The whole was ignited, at first gently, then to low redness, at the mouth of a muffle,* then cooled, a few drops of nitric acid added to oxidize the cupric oxide reduced by the filter, and then re-ignited. The ignition was continued until the weight became constant. The increased weight was the phosphoric oxide (P_2O_5). After ignition the cupric oxide and phosphate came out of the crucible in a beautiful coherent mass, leaving it perfectly clean and unharmed.

Disodic Phosphate.—It is quite difficult to obtain this salt anhydrous. It becomes so between 30° and 40°, but, as it fuses at 35°, it must be repulverized for analysis, and as it is quite hygroscopic, it is liable to change during the operation. A quantity dried over sulphuric acid was used, the phosphoric oxide being determined by ignition.

						per. ct.
(1)	1·1130 grms.	gave	·4576 grms.	$Na_4P_2O_7$	=	21·98 P_2O_5
(2)	1·2355	" "	·5075	"	" =	21·97 "

The mercurous oxide process with cupric oxide gave the following results.

						Found.	Theory.
(1)	1·0245 grms.	gave	·5124 grms.	P_2O_5	=	50·01	50·00
(2)	1·2198	" "	·4716	"	" =	38·66	21·97
(3)	·9200	" "	·2018	"	" =	21·93	"
(4)	1·2423	" "	·2730	"	" =	21·97	"

Number one was a specimen of anhydrous phosphate. It will be noticed that the second analysis is much too high. In this one the nitro-mercurous phosphate was placed in a mass in the center of the crucible and completely covered with cupric oxide. When the crucible was heated the cupric phosphate formed coated the outside of the pellet and prevented the further escape of the mercury. This proves the necessity of mixing thoroughly.

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* Justice is not done the muffle furnace. It gives an even, mellow heat which can be easily regulated, and for igniting precipitates it is unequaled. I have before spoken of the difficulty found in burning the filter with the aluminic phosphate. By placing it at the mouth of the muffle I was able to ignite it in the most perfect manner, without tipping the crucible, in less than ten minutes. Discretion must be used in placing the crucible in the muffle.

Care should be taken that the mercurous nitrate used is not basic. The salt used in this investigation was prepared in the following way. Pure mercury was dissolved, by aid of gentle heat, in pure nitric acid in a flat, open vessel. More mercury was now added and the whole boiled until every trace of nitrous acid was driven off. The solution was then allowed to crystallize. To the solution formed from these crystals metallic mercury is added to prevent the formation of mercuric nitrate. By this method the salt is obtained perfectly free from mercuric nitrate and the nitrites.

Ammonio-sodic phosphate.—As the ammonia present decomposes the mercurous nitrate, it is well to boil with a little caustic soda until it is driven off. In the first analysis magnesic oxide was substituted for the cupric oxide, but in every other respect the process was the same.

							Found.	Required.
(1)	1·3500	grms. gave	·3991	grms.	P_2O_5	=	29·56	29·36
(2)	·9832	" "	·2902	"	"	=	29·51	"
(3)	1·0803	" "	·3181	"	"	=	29·44	"
			Mean				29·50	

Ammonio-magnesic phosphate.—The solution was freed from ammonia as in the previous case. By ignition the following results were obtained.

(1) ·5936 grms. gave ·3664 grms. $Mg_2P_2O_7$ = 43·00 pr. ct. P_2O_5
(2) ·6135 " " ·4123 " " = 42·99 " "

By the mercurous nitrate process I obtained the following results:

(1) 1·0785 grms. gave ·4627 grms. = 42·92 pr. ct. P_2O_5
(2) ·9500 " " ·4084 " = 42·98 " "
Mean 42·95

Calcic phosphate.—This salt was obtained by precipitating calcic chloride with an excess of disodic phosphate. The precipitate was then carefully washed and dried. This was dissolved in as little nitric acid as possible. If the solution is too acid the precipitate is not formed until sodic hydrate is added. The nitro-mercurous phosphate was ignited with magnesic oxide. By this means the following results were obtained:

(1) ·6190 grms. gave ·1606 grms. P_2O_5 = 25·94 pr. ct.
(2) ·6765 " " ·1755 " " = 25·96 "
Mean 25·95

Mr. Waldo Lincoln employed this process in making an analysis of bone earth, and permits me to cite his results. The nitro-mercurous phosphate was ignited with cupric oxide.

	I.	II.	III.	IV.
Wt. taken	·5586	·4312	·7025	·6969
" SiO_2 found	·0009	·0007	----	----
" P_2O_5 "	·2367	·1487	·2421	·2396
Per cent SiO_2	0·16	0·16	----	----
" P_2O_5	42·37	34·48	34·46	34·38

Mean of P_2O_5 in three analyses, 34·44

The first analysis presents another instance of failure on account of the precipitate not being properly mixed with the cupric oxide.

Aluminic phosphate.—This was prepared by adding an excess of disodic phosphate to a solution of potash alum. The precipitate thus obtained was carefully washed and dried. The phosphate was dissolved in the least possible quantity of nitric acid and then treated as in the previous cases. An excess of nitric acid must be carefully avoided. The precipitate was ignited with cupric oxide.

(1) ·5685 grms. gave ·1634 grms. P_2O_5 = 28·77 pr. ct.
(2) ·5827 " " ·1672 " " = 28·69 "
(3) ·6720 " " ·1927 " " = 28·68 "
Mean 28·71

In order to test the process thoroughly it was thought best to determine the composition of this salt and then to compare the found with the calculated percentage. The water was estimated by simple ignition.

(1) ·8689 grms. gave ·2624 grms. H_2O = 30·18 pr. ct.
(2) ·8370 " " ·2525 " " = 30·17 "

The aluminic oxide was taken by difference yielding 41·12 pr. ct. These results lead to the formula

$$(Al_2O_3)_2(P_2O_5)+8H_2O$$

$$\text{or}\quad Al_2O_3+Al_2P_2O_8+8H_2O$$

showing it to be a basic aluminic phosphate.

	Calc. pr. cts.	Found pr. cts.
P_2O_5	28·86	28·71
H_2O	29·27	30·17
Al_2O_3	41·87	41·12

I attempted to determine ferric and uranic phosphates in the same way, but on the addition of the sodic hydrate the metallic oxides were precipitated, rendering this method worthless for them. The iron solution was then very largely diluted and precipitated without the addition of sodic hydrate, but all of the phosphoric acid could not be thrown down. Next the ferric was reduced to the ferrous salt by the addition of metallic iron, by passing a stream of sulphydric acid through the solution, and by the addition of sulphurous acid, but without better results. The phosphate was dissolved in potassic cyanide and the ammonio-magnesian solution added to precipitate the phosphoric acid. I hoped that potassic ferrocyanide would be formed which would remain in solution and allow the phosphoric acid to combine with the potassium. The experiment, however, proved unsuccessful, and with these results the further investigation of ferric phosphate was suspended.

Although the ignition with cupric oxide leaves nothing to be desired in point of accuracy, and is a much quicker method than any now in use, yet it was thought that some other agent might be employed which would hasten the process still more.

Stannic oxide was tried for this purpose. To a weighed quantity of pure tin* the nitro-mercurous phosphate was added, then sufficient nitric acid, sp. gr. 1·170, was poured upon the mass to oxidize the tin completely. The whole was evaporated to dryness on a radiator, ignited and weighed. The plan seemed very promising, but the results, from some unknown cause, were far from being satisfactory.

Another idea was to fuse the nitro-mercurous phosphate with some substance which had a low fusing point, so that the mercury might be volatilized, the phosphoric oxide remaining. Accordingly it was fused with free sulphur but some of the phosphoric oxide was always volatilized. Potassic dichromate and plumbic chromate were both subjected to trial, but as the results were very unsatisfactory, further investigation in this direction was abandoned.

These results prove conclusively the value of this process for the estimation of phosphoric acid in all cases except those of ferric† and uranic phosphates.

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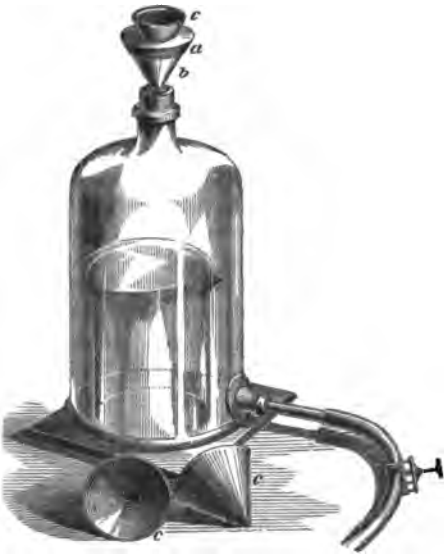
* Chemically pure tin can be obtained in considerable quantities, and with very little trouble, in the following manner. Ammonio-stannic chloride is first produced by adding to one molecule of stannic chloride, two of sal ammoniac. Dissolve in the least possible quantity of water and add an excess of chlorhydric acid, which causes the double chloride to crystallize out immediately. Purify completely by recrystallization from acid solutions. Dry the salt at 120°. Then fuse with an equal weight of a mixture of one part of potassic cyanide and one of potassic carbonate in a porcelain crucible On cooling a button of chemically pure tin will be found.

† Rose proposes in the case of ferric phosphate, to fuse the mercurous phosphate obtained with the mixed carbonates; then dissolve in dilute chlorhydric acid, and precipitate with the ammonio-magnesian solution. This will not effect a complete separation.

Otto's process of precipitating the phosphoric acid as ammonio-magnesic phosphate in the presence of tartaric acid was modified and tested as follows: Ferric phosphate was prepared by precipitating ferric chloride with disodic phosphate. The precipitate was thoroughly washed by decantation and then evaporated to dryness. By this means the phosphate was obtained as a light yellow powder. A weighed quantity of this was dissolved in dilute chlorhydric acid, sufficient tartaric

§ 3. *On the use of Porous Cones in Filtration.*

The sulphides of arsenic and antimony being quite easily obtained have long been regarded as furnishing the readiest and best means for the estimation of these two elements. A serious objection has however arisen in the fact, that they must be determined upon weighed filters, and that paper filters cannot be dried above 100° without danger of loss. Hence a filter which could be weighed easily and withstand a high temperature became a desideratum.



Taylor* accomplished this with sand filters, and obtained some excellent results. This method, however, requires experience and careful manipulation, reasons which will probably prevent its being generally used.

Under these circumstances the idea of using a cone made of very porous earthenware, and as a substitute for the paper filter, presented itself to me, and has been carried out in the following manner.

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acid added to keep the whole of the iron in solution, next ammonia in excess, the solution was then heated till it boiled briskly, and the ammonio-magnesian solution was added. The precipitate was ignited and weighed as magnesic pyrophosphate. This method gave the following results.

(1)	·6084	grms. gave	·3437	grms. $Mg_2P_2O_7$	=36·13	per cent.	P_2O_5
(2)	·7411	" "	·4173	" "	=36·02	"	"
(3)	1·0294	" "	·5805	" "	=36·11	"	"

Mean 36·09.

I would call especial attention to the fact, as it shortens the process considerably, that the phosphate solution was boiling when the ammonio-magnesian solution was added. Dr. Gibbs found that when the ammonio-magnesic and ammonio-manganic phosphates were precipitated from boiling solutions, that on cooling they came down as beautiful, highly crystalline precipitates, which, instead of requiring twenty-four hours for precipitation, were ready to be filtered within an hour. This method has been in use in this laboratory for the past six months, and has met with uniform success. It applies as well to the estimation of phosphoric acid as to that of magnesium and manganese.

With this additional treatment for the separation of iron, it is believed that this process will apply to the majority of cases met with in practice.

* This Jour. II, vol. xliv, p. 215.

The cones* are made of very light, porous earthenware, and have an angle of about sixty degrees. They are used in the following way:

A section of a seamless rubber tube *a*, is stretched around the mouth of a funnel *b*, preferably a Bunsen funnel, allowing a portion of the tube to project above the top. This part will immediately arrange itself at right angles to the top of the funnel; into the circle thus formed the cone *c*, is put. It is then connected with the Bunsen pump. When the cone is moistened and the pressure applied, the rubber band forms an air-tight joint and the liquid runs through with great rapidity. Before the cones are applied to quantitative work they must be carefully washed, first with concentrated chlorhydric acid, then with distilled water, dried, and weighed. A small porcelain crucible was always kept at the balance in which to weigh them. With this apparatus the following results have been obtained.

A sample of ordinary crystallized potassio-antimonylic tartrate gave

(1) 1·1069 grms. gave ·5570 grms. Sb_3S_3=35·94 pr. ct. Sb.
(2) 1·6985 " " ·8550 " " =35·96 " "
Mean 35·95.†

A specimen of the same salt carefully recrystallized, gave upon analysis the following data.

(1) ·7755 grms. gave ·3955 grms. Sb_2S_3=36·40 pr. ct. Sb.
(2) ·6050 " " ·3085 " " =36·42 " "
Mean 36·41.

Mr. W. Lincoln also made an analysis of the same salt by means of the cones, and kindly permits me to use his results.

(1) ·4683 grms. gave ·2388 grms. Sb_2S_3=36·41 pr. ct. Sb.
(2) ·8135 " " ·4144 " " =36·38 " "
Mean 36·40.

In all of these analyses Sb=120.

The Sb_2S_3 was precipitated in the manner recommended by Sharples.‡ It is necessary that the boiling should proceed for some time, a brisk current of sulphydric acid being passed through the liquid. The precipitate is then filtered upon the weighed cone and the whole dried in an air bath at 300°. The antimonous sulphide is at this temperature converted into the gray crystalline modification.

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* Much credit is due to the firm of A. W. & H. C. Robertson of Chelsea, Mass., who, by their superior mechanical skill, have aided me much in accomplishing the desired result.

† Taylor obtained as the mean of three analyses 36·08.

‡ This Jour., II, vol. 1, page 248.

No formula has yet been found which agrees with either of the percentages obtained. As the atomic weight of antimony is differently stated from 120 to 122, this is easily explained.

It is unfortunate that the atomic weight of antimony is yet so uncertain, but it is hoped that these results, agreeing so closely among themselves, will be accepted as proving the value of the process.

Arsenous Oxide.—This was the next substance analyzed. The sulphide was precipitated in the usual manner, but it was noticed that by having the solution decidedly acid and passing through it a very rapid stream of sulphydric acid, that the sulphide was obtained in a more granular condition.

The precipitate can be dried with impunity at 120°. At 140° the lemon-yellow sulphide commences to change to red, and at 180° is completely converted into the liver-red variety.

With ordinary commercial arsenous oxide, the following results were obtained.

							Found pr. cts.	Theory pr. cts.	
(1)	1·7940	grms.	gave	2·2260	grms.	As_2S_3	=75·64	75·76	As.
(2)	·5770	"	"	·7165	"	"	=75·84	"	"
(3)	·8520	"	"	1·0579	"	"	=75·68	"	"

Mean 75·72

Mr. Lincoln obtained as the result of two analyses:

							Found pr. cts.	Theory pr. cts.	
(1)	·8926	grms.	gave	1·1087	grms.	As_2S_3	=75·76	75·76	As.
(2)	·8145	"	"	1·0128	"	"	=75·77	"	"

Mean 75·76

These results show that this process renders the estimation of antimony and arsenic one of the simplest and most accurate operations in quantitative analysis.

The cones can be used repeatedly and can replace paper filters in every case. They will undoubtedly be found to be of great value in commercial work, for drying crystals and filtering corrosive liquids. As they will stand sudden changes of temperature without breaking, they can be substituted to advantage in many cases for crucibles.

In closing, I desire to return my sincere thanks to my kind teacher, Dr. Gibbs, who has furnished me with the material for these investigations, and has aided me by his counsels and advice.

Cambridge, March 13th, 1871.

ART. L.—*On certain Glacial and Post-glacial phenomena of the Maumee Valley;* by G. K. GILBERT, A.M.

THE observations, upon which the following remarks are chiefly based, were made during the summers of 1869 and 1870 for the Ohio Geological Survey, and are here published, with permission, in advance of the official report.

I. The Maumee occupies a broad shallow valley with easy slopes and without definite boundaries. It is the westward prolongation of the trough occupied by Lake Erie, and includes the upper waters at least of the Wabash river as well as the entire basin of the Maumee. The highest point along the axis of the valley is at Fort Wayne, one hundred miles from Lake Erie, and is but 185 feet above the present level of that lake, so that the descent of the Maumee eastward is less than two feet per mile; the sides of the valley rise with a slope nearly as moderate to an altitude of 300 to 400 feet above the median line. So nearly does it approximate to a plain that the consequences of the earth's sphericity are not cancelled, and an observer on one side is prevented from seeing the opposite by the interference of the intervening land.

The rock surface is covered by a sheet of drift, that masks its minor irregularities and contributes to the general impression of a plain. Where the drift has been freshly removed by the wash of waves or currents, the surface of the underlying rock is shown to be planed, striated, and furrowed by glacial action. The general bearing of the striæ, subject to local deflection from details of contour, is parallel to that of the valley. At Sandusky City, and on Kelley's, South Bass, and West Sister Islands it is S. 80° W.; at Fremont and Genoa, east of Toledo, S. 65° W.; at various points in Lucas county, west of Toledo, S. 55° W.; and along the Auglaize river near Defiance, S.W. Farther south the bearing is still more southerly, being S. 35° W. at Lima, O., and S. 15° W. at Middlepoint near Van Wert. That the motion to which this system of striæ is due was southwestward—up the valley of the Maumee as it now lies,—and not in the opposite direction, is attested by some flint nodules contained in limestones of the Waterlime Group on West Sister island and at Monclova near Toledo. By reason of their superior hardness, they were able to resist, better than the limestone, the grinding action, and they project boldly from the planed surfaces, protecting and maintaining each upon its west or lee side, a train or ridge of undisturbed limestone.

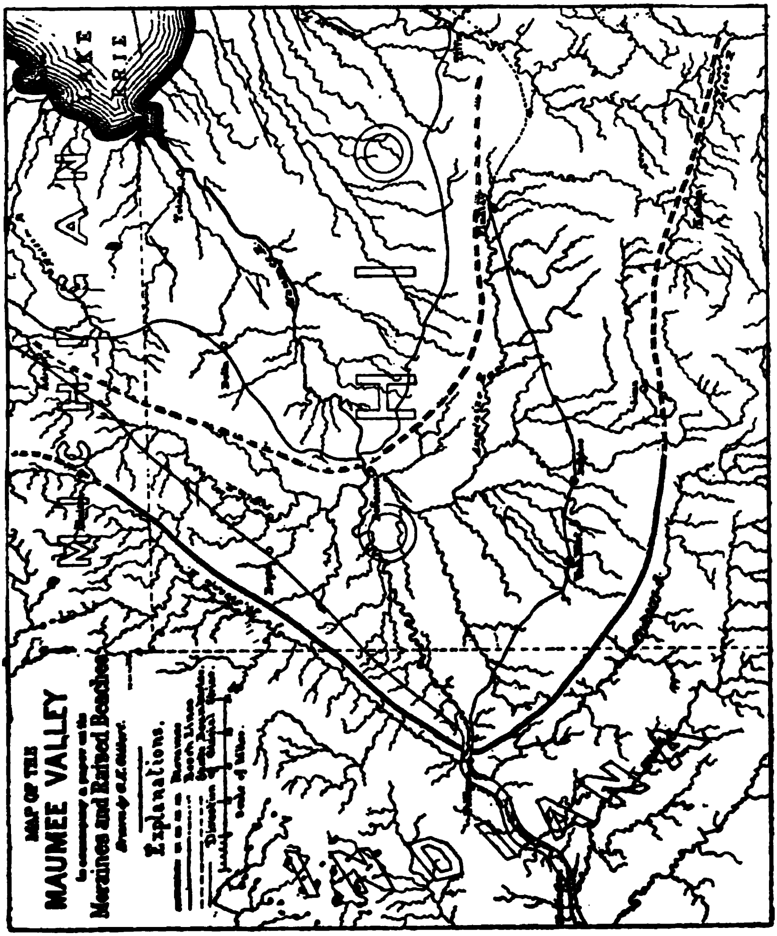
The overlying drift is in chief part a blue clay—the Erie Clay of Sir William Logan—containing irregular, lenticular beds of sand and gravel, and abundant, but unequally distributed, glaciated boulders of all sizes up to a diameter of twenty feet. It has already been recognized by Dr. Newberry as the sediment of a sea or ocean flanked by glaciers and floating rock-laden icebergs; and every phase that has fallen under my own observation has served to confirm the identification. Its more elevated portions, which have been exempt from lacustrine action, present a rolling surface with frequent, undrained hollows, occupied by lakelets or the deep swamps that have resulted from their slow filling; while at and below the level of 220 feet (above Lake Erie) this surface has been remodelled and levelled by the waves, currents and sediments of Lake Erie.

Premising thus much of the general character of the valley, I will now ask the reader to notice, upon the accompanying map, some peculiarities of the arrangement of the watercourses. North of the Maumee river, where the land slopes to the southeast, most of the rivulets flow in that direction; but the principal streams, the St. Joseph and Tiffin rivers, cross the system at right angles. Moreover, all the tributaries of the St. Joseph come from the northwest, while the country east of it is drained by branches of the Tiffin, the divide between the waters of the two streams running within five miles of the former. This feature is caused by a narrow step in the country,—a natural embankment, that carries the St. Joseph across the face of the slope, as a mill-race is carried along the bank of a stream; and that river may be said to result from the confluence of eastward-flowing creeks that have found a barrier in the ridge which forms its eastern bank. The slopes of this ridge are quite gentle and the height is moderate; west of Bryan, where it is crossed by a branch of the Lake Shore and Michigan Southern Railway, it rises to an altitude of fifty feet, while at the north line of Ohio it is barely distinguishable. Superficially it everywhere presents the same rolling gravelly clay as the surrounding country.

South of Fort Wayne the same phenomena are presented by the St. Marys river. The slope of the country is toward the northeast, yet its course is to the northwest. Its tributaries are from the south and west, while its right bank is drained by branches of the Auglaize. Where the dividing ridge has been measured, it has an altitude of 35 to 50 feet.

A correlated feature of the two streams—the St. Marys and St. Joseph—is that, forming the sides of a right angle, they unite at its apex, and the resultant river returns within the angle.

The page of history recorded in these phenomena is by no means ambiguous. The ridges, or, more properly, the ridge which determines the courses of the St. Joseph and St. Marys rivers is a buried terminal moraine of the glacier that moved southwestward through the Maumee valley. The overlying Erie Clay covers it from sight, but it is shadowed forth on the surface of that deposit, as the ground is pictured through a deep and even canopy of snow. Its irregularly curved outline accords intimately with the configuration of the valley, and with the direction of the ice markings; its concavity is turned toward the source of motion; its greatest convexity is along the line of least resistance. The notch at Fort Wayne, through which the Maumee flows, was perhaps first cut by the river to which the retiring glacier gave rise, but has certainly been cleaned of the subsequent deposit of clay by a later current,—



to be described farther on. While it affords no section of the moraine for examination, it yet confirms the general fact of its existence, by demonstrating that the superficial ridge has here no nucleus of rock *in situ*. With the exception of the Maumee, no stream crosses the moraine from near Hudson, Michigan, to Fort Amanda, near Lima, Ohio, a distance of 83 miles in a right line and 120 miles on the line of the moraine. Beyond these points I have not traced it, but an inspection of the map suggests that it may be found along the upper waters of the Tiffin and Scioto rivers, as dotted in the accompanying chart. This would increase its length and chord to 200 miles, and 120 miles, respectively.

The courses of the Tiffin and Auglaize rivers are determined by a more easterly, and so more recent, moraine of the same system, but its form is less conspicuous, as this portion of the valley has been greatly modified by làcustrine action. The same agency has obliterated all superficial traces, if any existed, of minor moraines.

South of the St. Marys river are other and numerous moraines accompanied by glacial striæ. Their character and courses have not yet been studied; but their presence carries the mind back to an epoch of the cold period, when the margin of the ice-field was farther south, and the glacier of the Maumee valley was marged in the general mass. As the mantle of ice grew shorter—and, in fact, at every stage of its existence—its margin must have been variously notched and lobed in conformity with the contour of the country, the higher lands being first laid bare by the encroaching secular summer. Early in the history of this encroachment the glacier of the Maumee valley constituted one of these lobes, and has recorded its form in the two moraines that I have described.

II. That Lake Erie formerly had an outlet past Fort Wayne, Indiana, and down the Wabash valley, has for some years been recognized by local observers;* but, as there is reason to believe that the fact is as yet unpublished, an account of it will not be without interest to the public. I was led to make an examination of this outlet by its relation to certain cotemporaneous beach lines that I had occasion to examine and trace in Ohio.

The relation of the waters of the Great Lakes to their shores has undergone a series of changes since it was first established, by the recession or drainage of the iceberg-bearing sea, at the close of the Drift period. Some of these changes appear to have been gradual and others comparatively sudden, while the intervals of rest are plainly marked by the beach lines, of which a series is presented near the borders of each of the lakes, outlining their ancient limits. In the Maumee valley four of these periods of rest are distinctly recorded, the water levels being marked at 220, 195, 165 and 90 to 65 feet, above Lake Erie, along the line of the Air Line branch of the Lake Shore and Michigan Southern Railway, running west from Toledo. Two of these beach lines have been traced for some distance across the country, and their courses are marked on the accompanying map. The lower of the two is the one at 165 feet. Lake Erie then stretched sixty miles up the valley to the site of the town of Defiance, covering all that country now known as the Black Swamp. The upper beach is the highest of the series, and records a lake level at Adrian, Bryan and Columbus Grove of 220 feet above the present, of 210 feet at Delphos, and of 205 feet at New Haven, six miles east of Fort Wayne. Toward the latter point the beach lines converge, coming from the northeast and southeast; but, instead of uniting, they become parallel, and are continued as the sides of a broad water-course, through which the Great Lake Basin then discharged its surplus waters. At New Haven this channel is not less than a mile and a half broad, and has an average depth of 20 feet, with sides and bottom of drift. For twenty-five miles this character continues, and there is no notable fall. Three miles above Huntington, Indiana, however, the drift bottom is replaced by a floor of Niagara limestone, and the descent westward becomes comparatively quite rapid. At Huntington the valley is contracted in width to one mile, and is walled, on one side at least, by rock *in situ*. In the eastern portion of this ancient river bed the Maumee and its branches have cut channels fifteen to twenty-five feet deep, without meeting the underlying limestone. Most of the interval from Fort Wayne to Huntington is occupied by a marsh, over which meanders Little river, an insignificant stream whose only claim to the title of river seems to lie in the magnitude of the deserted channel of which it is sole occupant. At Huntington the Wabash river emerges from a narrow cleft of its own carving, and takes possession of the broad trough to which it was once but a humble tributary. The limestone above Huntington is the rocky rim or dam which determined the altitude of the overflow at this point, and is 170 feet above the present level of Lake Erie. Above it the stream must have resembled the Detroit, bearing a smooth surface, but with enough current to excavate its soft bottom somewhat deeply where the marsh and prairie of the Little river now are spread; below, it was more comparable to the Niagara at Buffalo, where it rushes over the outcrop of the Corniferous limestone. At Fort Wayne the St. Joseph and St.

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* The fact was suggested to me before I visited the locality, by Martin Arrowsmith, Esq., of Farmers' Centre, O., and was realized less perfectly by several gentlemen whom I met in Indiana.

Marys contributed their waters. Their mouths were more than fifty feet higher than now, and the flood-plains of gravel and sand, which they then formed, now flank their valleys as terraces, and can be traced for forty miles toward their sources. When, by the retiring of the lake, they were united, but slight cause was needed to turn them eastward along the level bottom of the deserted channel, and they have now cut their beds so deeply in the drift, that the highest freshets do not connect them with the Little river.

In addition to its general interest, the fact of this ancient, southwesterly lake-discharge is an important element in the study of the nature of the changes, in virtue of which the lakes have stood at so many different levels since the ice-period. The idea suggested by Dr. Newberry (in a paper before the Boston Society of Natural History in 1862), that they may have been due to local, rather than continental, upheaval and depression, receives here strong confirmation. At the point where Lake Michigan once found outlet southward through the Desplaines river,* the rocky barrier is but four feet above the present level of that Lake, and seventeen feet above Lake Erie. A barrier of drift may have existed one hundred feet higher. At the Wabash outlet the rocky rim is 170 feet above Lake Erie, and was probably covered by fifty feet of drift. And at Lewiston, where the Niagara commenced its work, the elevation of the rim is 38 feet higher than the present Lake.†

The order in which these channels were opened and deserted, is not yet known, but whatever sequence is supposed, it is equally evident that the changes that produced it must have involved the tilting and warping of the land. At whatever time the Wabash valley received the discharge, the barriers, east and west, must have been relatively much higher than at present. To restore now the old water level and current at Fort Wayne, we would need, not merely to fill the gorge of the Niagara, and renew the escarpment at Lewiston, but to construct on that escarpment a retaining wall 170 feet high and many miles in length; and, after filling the valley of the Desplaines to the height—one hundred feet—of the adjacent drift hills, another hundred feet would be needed to complete the dam. Just what has been the warping of the basin to produce this contortion of the rim, I am not prepared to say, but the problem is not insoluble. The lines of bluffs, shingle, ridges and dunes, that mark the limits of the water at its various stages, are plain and faithful records, and their tracing cannot fail to throw light on the character and the order of the undulations which have affected the valley of the lakes in post-glacial time. The field for exploration is large, and the data already accumulated inconsiderable, but we may hope the geological surveys now in progress in Ohio, Indiana and Michigan, and in Canada, will in a few years develop the whole subject.

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* This outlet is described by Dr. E. Andrews in his recent paper on "The North American Lakes considered as chronometers of post-glacial time" (Trans. Chicago Acad. Sci., vol. ii, p. 14); and the additional data here given in regard to it were kindly furnished me, by the same gentleman, in a private letter.

† Nat. Hist. of New York, Geology of Fourth District. By James Hall, p. 384. It is interesting to note, in passing, that the containing rock was in each case the Niagara limestone, and that a deep gorge has been cut at Niagara only, because there alone was an underlying softer rock exposed.

ART. LI.—*Memorandum on the Amphipleura pellucida;* by J. J. WOODWARD, Assistant Surgeon, U. S. Army.

THE attention of microscopists has frequently been directed, of late years, to the *Amphipleura pellucida* or *Navicula acus*, as a test object well suited to try the defining powers of the very best object glasses. The length of this diatom is stated by Pritchard as ranging from $\frac{1}{140}$th to $\frac{1}{300}$th of an inch. The average length is given by the Micrographic Dictionary at ·0044 of an inch. The striæ, which are exceedingly difficult, were first described by Messrs. Sollitt and Harrison, who estimated them at from 120,000 to 130,000 to the inch. Their estimate has been adopted by the Micrographic Dictionary and by the majority of modern writers who have referred to this test; but so many difficulties beset the resolution that few microscopists appear to have attempted to verify the original estimates. Indeed most observers would seem to have been unsuccessful in their efforts to resolve the Amphipleura even with the best objectives and some have gone so far as to deny the existence of any striæ upon the frustules of this species.

Among the microscopists who claim to have seen the striæ, several would seem to differ from the original estimates of Sollitt and Harrison as to their fineness. Dr. Royston Pigott, whose papers on "high-power definition" in the Monthly Microscopical Journal have recently attracted much attention, sets down their number at 150,000 to the inch. Dr. Carpenter, on the other hand, in the 4th edition of "The Microscope and its Revelations," expresses the opinion that even the estimates of Messrs. Sollitt and Harrison are too high: and we are told by Mr. Lobb (Monthly Microscopical Journal, vol. iii, p. 104) that Mr. Lealand has recently "succeeded in counting the Amphipleura lines and finds them 100 in $\frac{1}{1000}$th of an inch."

A few months ago two slides of *Amphipleura pellucida* were received at the Army Medical Museum from Messrs. Powell and Lealand, and I succeeded in obtaining excellent resolution by the immersion $\frac{1}{16}$th of these makers. The frustules on the two slides were found to measure from $\frac{1}{170}$th to $\frac{1}{400}$th of an inch in length. Resolution could be satisfactorily effected and the striæ counted on any of them. I took eight successful negatives from medium size and small frustules, and verified the counts made in the Microscope by counting the striæ on the glass negatives. I found the striæ on medium sized frustules, say $\frac{1}{200}$th of an inch in length, counted usually from 90 to 93 striæ to the $\frac{1}{1000}$th of an inch; in that selected for the two photographs which accompany this memorandum the number was 91 to the $\frac{1}{1000}$th of an inch. Larger frustules exhibited rather coarser, smaller ones rather finer striæ. On the smallest frustules at my disposal, several of them only $\frac{1}{400}$th of an inch in length, I found no example in which the number of striæ exceeded 100 to the $\frac{1}{1000}$th of an inch. The striæ of these smallest and most difficult frustules do not then rival in fineness the nineteenth band of the Nobert's plate, as has been asserted by some; they compare rather with the sixteenth and seventeenth bands.

After making the photographs I extended my observations to a number of other slides of *Amphipleura pellucida* including two of the original specimens from Hull, kindly sent to the Museum some time since by Mr. W. S. Sullivant, of Columbus, Ohio, and the example in the First Century of Eulenstein. I found that different slides varied considerably in the ease with which I could resolve them, chiefly as I think on account of the thickness of the glass covers, which in several instances did not permit the best work of the immersion $\frac{1}{16}$th. Perhaps, however, the markings on some frustules may be shallower than on others whose striæ count the same number to the $\frac{1}{1000}$th of an inch. In any event I have found, as yet, no slides the covers of which permit the $\frac{1}{16}$th to be appproximately adjusted, on which it was impossible to resolve the frustules, and no frustules the striæ of which exceeded 100 to the $\frac{1}{1000}$th of an inch.

The best resolution I was able to obtain by ordinary lamp light was not very satisfactory. I used therefore, during the investigation, direct sunlight, rendered monochromatic by passage through the solution of ammonio-sulphate of copper. A parallel pencil of such light was concentrated by the achromatic condenser, which was suitably decentred to attain obliquity. The same illumination was employed in making the photographs. I have since had the pleasure of exhibiting the resolution in quite as satisfactory a manner to several microscopists by monochromatic light obtained from the electric lamp.

War Department, Surgeon General's Office,
Army Medical Museum, Feb. 1, 1871.

ART. LII.—*Memorandum on the Surirella gemma;* by J. J. WOODWARD, Assistant Surgeon, U. S. Army.

THE *Surirella gemma* has been recommended by Hartnack as a test for immersion objectives of high powers. I have not gained access to his original description, but find accounts of his views, with figures, in the works of Drs. Carpenter and Frey. ("The Microscope and its Revelations," 4th edition, p. 182. "Das Mikroskop," 3d edition, p. 40.) Hartnack observed fine longitudinal striæ in addition to the fine transverse ones previously known to exist between the large transverse ribs; he supposed the true markings to have the form of elongated hexagons.

Two handsome slides of this diatom were received at the Army Medical Museum a few months since, from Bourgogne of Paris. A careful study of these by monochromatic sunlight inclines me to the opinion that Hartnack's interpretation is erroneous, and that the fine striæ are in reality rows of minute hemispherical bosses; from which, as in the case of other diatoms, the appearance of hexagons would readily result if the frustule was observed by an objective of inferior defining power to that I used, or if the illumination was unsuitable. This memorandum is accompanied by two photographs exhibiting what I saw; one is magnified 1,034, the other 3,100 diameters. The principal frustule shown in these photographs is $\frac{1}{300}$th of an inch in length. (The mean length of *S. gemma* is stated by the Microscopic Dictionary at $\frac{1}{340}$th of an inch.) The fine transverse striæ counted longitudinally at the rate of 72 to the $\frac{1}{1000}$th of an inch. Transversely these were resolved into beaded appearances which counted laterally 84 to the $\frac{1}{1000}$th of an inch. If the structure consists, as I suppose it does, of fine hemispherical bosses, projecting from the surface of the frustules, the fact that these bosses are set together more closely in the transverse direction than in the longitudinal would account for the elongated form of the pseudo-hexagons when seen.

Some parts of the photographs closely approach Hartnack's description, but it is easy to observe that these are not the parts which are most nearly in focus.

I have also resolved this diatom by monochromatic light derived from the electric lamp. The appearances obtained were identical with those above described.

War Department, Surgeon General's Office,
Army Medical Museum, Feb. 1, 1871.

LIII.—*Calorimetric Investigations;* by R. Bunsen.*

(Continued from page 282.)

2. *The Determination of specific heat.*

The simplest way of obtaining the specific heat of a substance is to determine once for all the amount of heat, expressed in scale divisions, which *one* gram of water loses in cooling from 1° C. to 0° C., and to divide by the value W_w thus formed, the quantity of heat W, measured on the same scale, which one gram of the substance loses for the same difference in temperature. If the weight of the substance is G, its temperature t, the number of corrected divisions which the mercury thread of the scale has advanced T, then the specific heat desired results from the equation

$$S = \frac{T}{W_w G t}, \quad - \quad - \quad . \quad - \qquad (6)$$

in which, for t, the boiling point of water, corresponding to the state of the barometer during the experiment, is to be taken.

In order to communicate to substances the constant temperature t, use is made of the apparatus, fig. 4 (p. 173), which is drawn to a scale of $\frac{1}{8}$ of its real size. The tin vessel A, which is provided with a water guage, contains as much water as is necessary in order that, by means of the small gas lamp underneath, a continual jet of steam of 12 hours duration may be produced. The steam enters through the rubber tube a, and the outer glass vessel B into the rubber tube b, which communicates with an ordinary condenser. Within the vessel B, which is filled with continually renewed steam, is the heating vessel f, in the form of an ordinary thin walled test-tube whose upper opening is not widened out but somewhat narrowed and cut off sharply. The opening projects several millimeters above the rubber stopper closing the outer vessel B. When the body to be warmed has remained in the vessel f, which is surrounded on all sides by steam, about one hour, then the whole apparatus, through which the steam still flows, is held by means of the cork ring n; the still closed mouth p is on the likewise closed mouth δ (fig. 1) of the snow-surrounded calorimeter, the stoppers are rapidly removed, while almost simultaneously, by tilting the heating apparatus B, the heated body is allowed to fall into the water a, fig 1. The time consumed in falling amounts to only a very small fraction of a second, so that the cooling during the same may be considered as vanishingly small.

On the bottom of the inner vessel a, fig 1, is contained a small, perfectly moistened plug of loose cotton wool, which, to prevent its rising, is twisted around a coiled platinum wire. This cotton answers a double purpose: in the first place it prevents the glass vessel from being injured by the falling in of specifically heavy bodies; then in addition it aids in the removal from the apparatus of the substances which have been used in the experiment. To effect this, a properly bent wire is bored into the cotton, which, with the substance resting upon it, is drawn therewith to the mouth of the tube, the substance is removed and the cotton without being taken out of the vessel is returned by means of the wire to its former place.

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* Translated for this Journal, with permission of the author, from Poggendorff's Annalen der Physik und Chemie, Bd. cxli, by Dr. G. E. Moore, of San Francisco.

The principal advantage, which, independent of its great delicacy, the instrument just described possesses over all other calorimetric contrivances is, that the entire heat which the heated body evolves is employed, without any loss, in the ice melting: the weights of the substances which give up their heat to the 0° C. cooled water of the vessel *a*, fig. 1, is so small compared with the weight of this water, that the temperature can never rise to 4° C. As the water has at this temperature its maximum density, the fluid which warms itself on the bottom of the vessel *a* can never rise, and is protected from every loss of heat, not employed in ice melting, by a high superincumbent water column at 0° C., whose conducting capacity for heat is vanishingly small. This circumstance may be observed very beautifully on the ice cylinder, when it has been used for 30 to 40 experiments. There is then to be found in the ice, quite far down on the bottom, where the vessel *a* is rounded off, a hollow space, melted out and filled with water, which possesses the very regular form of a small glass matrass, while the ice cylinder above this part appears throughout its whole extent entirely unaltered.

The weight of the substance to be investigated need be, according to the specific heat to be expected, no greater than 0·3 grams, to at most 4 grams. If the substance is a fluid, or if it is subject to alteration by the access of air or water, it is, as in an organic analysis, sealed in the lightest possible glass case, whose weight is determined in weighing the substance. If the substance floats on water, either above or with the enclosing glass case, it is loaded in addition with a likewise weighed spiral of platinum wire, heavy enough to effect the immersion. It would probably be still more convenient to employ in all cases a light, tightly closing platinum vessel. The amount of heat which the glass case and platinum spiral emit is included in the calculation in the following manner: Let the weight of the glass case be called G_g, its temperature *t*, and the amount of heat, measured in scale divisions, which one gram of the glass of the case emits on cooling from 1° C. to 0° C. W_g, and let the same factors for platinum be denoted by G_p, t and W_p, then equation (6) will be transformed into

$$S = \frac{\frac{T}{t} - (W_g G_g + W_p G_p)}{W_g G} \quad - \quad - \quad - \quad (7)$$

The constants W_g, W_p and W_w are first to be determined (once for all), W_p results with the aid of the equation

$$W_p = \frac{T}{Gt}$$

from the following observations, in which G denotes the weight of platinum employed in the experiment:

$T = 215{\cdot}6$
$t = 100^\circ{\cdot}0$ C.
$G = 4{\cdot}5942$ grams
whence: $W_p = 0{\cdot}4692$

W_g was calculated by the same equation from the following observations conducted on two kinds of glass, by which the weight of glass employed in the experiment is denoted by G, and the elements for the determination of T according to equation (5) are likewise given.

TABLE 2.

		Glass, kind I.	Glass, kind II.	
		Expt. 1.	Expt. 2.	Expt. 3.
Weight of the glass, - -	G	0·5706 grm.	1·0114 grm.	1·4319 grm.
Temperature of the glass, -	t	99°·74 C.	99°·474 C.	99°·474 C.
Duration of the experiment, -	$M_1 - M_0$	29′	87′	56′
Movements on scale before the experiment, - - - -	$\frac{\tau_0}{m_0}$	$-0{\cdot}1$	0·0	$+0{\cdot}005$
Movements on scale after the experiment, - - - -	$\frac{\tau_1}{m_1}$	$-0{\cdot}1$	0·0	$+0{\cdot}014$
Oscillation on the scale, -	$Q_0 - Q_1$	159·1	287·9	410·4

For the first sort of glass, $W'_g = 2{\cdot}7446$;
for the second $W_g = 2{\cdot}8616$
$W_g = 2{\cdot}8777$

Mean $2{\cdot}8697$

W_w is obtained from the two following experiments by means of the equation

$$W_w = \frac{\frac{T}{t} - (W_g G_g + W_p G_p)}{G}$$

TABLE 3.

		Expt. 1.	Expt. 2.
Weight of the water, - -	G	0·3333	0·3333
Weight of the glass case, -	G_g	0·2223	0·2223
Weight of the platinum load,	G_p	0·5230	0·5230
Temperature communicated,	t	99°·474 C.	99°·474 C.
Duration of the experiment, -	M_1-M_0	76′	86′
Movements on the scale before the experiment, - - -	$\frac{\tau_0}{m_0}$	0·0	+0·067
Movements on the scale after the experiment, - - -	$\frac{\tau_1}{m_1}$	0·0	+0·064
Observed divisions on the scale,	Q_0-Q_1	573·9	568·1
Constants, - - -	$W_p=0·4692$; $W_g=2·870$		

The calculation gives: from experiment 1: $W_w=14·660$
" " 2: $W_w=14·654$
in the mean $W_w=14·657$

For the explanation of the method already described, I append the results of several determinations conducted on chemically pure substances, whose specific heat has been determined with great accuracy by the previously customary method of mixture. The elements of observation in these experiments are to be found arranged in the following table 4, whose lettering relates to equations (5) and (7).

TABLE 4.

Substance investigated.		Cast silver.	Cast zinc.	Cast antimony.	Cast cadmium.	Very old roll sulphur
Weight of the substance,	G	3·6320	2·5150	3·8575	1·8675	1·0708
Weight of the glass case,	G_g	0	0	0	0	0
Weight of the platinum load, - -	G_p	0	0	0	0	0
Temperature communicated. - -	t	100°·00 C.	99°·80 C.	99°·80 C.	99°·80 C.	100°·00 C.
Duration of the experiment, - -	M_1-M_0	60′	60′	64′	63′	55′
Movements on scale before the experiment,	$\frac{\tau_0}{m_0}$	0	0	0	0	0
Movements on scale after the experiment,	$\frac{\tau_1}{m_1}$	0	0	0	0	0
Oscillation on the scale,	Q_0-Q_1	297·7	343·8	279·5	146·7	268·8
Constants, -	$W=14·657$					

In the following table 5, are to be found the specific heats computed from these values, together with the ones found by Regnault by the method of mixture.

TABLE 5.

Substances.	Ice calorimeter. *a.*	Regnault. *b.*	*a—b.*
Water,	1·0000	1·0000	....
Silver,	0·0559	0·0570	—0·0011
Zinc,	0·0935	0·0956	—0·0021
Antimony,	0·0495	0·0508	—0·0014
Cadmium,	0·0548	0·0567	—0·0019
Sulphur,	0·1712	0·1764	—0·0052

It will be seen that the values obtained with the ice calorimeter agree very closely with those obtained by Regnault by means of the method of mixture, but have always been found somewhat smaller. Whether this constant deviation has its origin in the difference in the methods employed can be the less decided from these few experiments as they were conducted, to be sure with the avoidance of all considerable sources of error, but without special care, while I was at the same time occupied in other labors.

The following table 6, contains experiments made with several pure elements whose specific heats could not previously be determined. The specific heats and atomic heats calculated therefrom, are arranged together in table 7.

TABLE 6.

Substance investigated.		Indium.	Indium.	Ruthenium.	Calcium.	Calcium.	Allotropic tin.	Ca
Weight of the substance,	G	1·1514	1·1514	1·7927	0·2823	0·2823	2·2394	3
Weight of the glass envelop,	G_g	0	0	0·3287	0·6683	0·6683	0·3953	
Weight of the platinum load,	G_p	0	0	0·4239	0·4239	0·4239	0	
Temperature communicated,	t	99°·78 C.	99°·82 C.	99°·60 C.	99°·78 C.	99°·78 C.	99°·786 C.	99°·1
Duration of the experiment,	M_1-M_0	46′	47′	106′	65′	76′	66′	
Movements on the scale before the experiment,	$\frac{\tau_0}{m_0}$	—0·130	—0·063	—0·160	—0·090	—0·052	—0·120	0
Movements on the scale after the experiment,	$\frac{\tau_1}{m_1}$	—0·020	—0·037	—0·110	—0·130	—0·076	—0·16	0
Oscillation on the scale,	Q_0-Q_1	100·2	97·5	276·8	280·2	277·[illegible]	296·0	2

Constants, - $W_g=2·745$; $W_p=0·4692$; $W_w=14·657$

In relation to the material employed in these experiments and the results obtained therewith, the following is to be remarked. The ruthenium was prepared from the perfectly osmium-free so-called iron residues of the mint of St. Petersburg. For this purpose the gray powder was taken, which

TABLE 7.

Elements.	Specific heat. a	Atomic weight. b	Atomic heat. $a \times b$
Ruthenium, ...	0·0611	52·0	3·18
Calcium, ...	0·1722	20·0	3·44
"	0·1686	20·0	3·37
Allotropic tin, . .	0·0545	58·8	3·21
Cast tin, ...	0·0559	58·8	3·39
Indium, ...	0·0574	37·8	2·17
"	0·0568	37·8	2·13

remains after the disintegration of this material with barium chloride in a stream of chlorine gas, and which gives by melting with potassic hydrate a copious yield of potassic ruthenate. The oxide thrown down from this salt by fractional precipitation with carbonic acid was converted into chloride with hydrochloric acid, the aqueous solution of this latter salt was precipitated with hydrogen gas, and the metal, in the state of lustrous scales, was ignited in a current of hydrogen to remove every trace of oxide. It proved on examination to be entirely free from the other platinum metals. The specific heat found therefor accords, as might be expected, with the previously accepted atomic weight.

The calcium was reduced by electrolysis from melted calcium chloride. It formed small pale golden-yellow globules with a high metallic luster, which take in the air, very rapidly, a grayish tarnish. Before enclosing in the glass envelope, they were shaved bright in an atmosphere of carbonic acid. Upon examination, it proved to be almost entirely pure. From the atomic heat thus found, it may be concluded that the previously accepted atomic weight $C_a=20$ is the correct one, and need not, as has become necessary with the atomic weights of the alkali metals, be halved.

Under allotropic tin is understood the singular modification of this metal, which appears to form from ordinary tin by long continued very low temperature. The specimen investigated came from the large mass, altered by the cold of an unusually long and severe winter, on which Fritzsche had observed this remarkable allotropy, first described by him. The mass consisted of an aggregate of small undeterminate angular rods loosely coherent in one direction, which crumbled by even slight pressure. This tin possesses, as I have convinced myself, a high degree of purity, contains no trace of antimony or arsenic, and dissolves completely in potassium trisulphid without leaving any basic metallic sulphids. The small rods of which it consists are not brittle but ductile like ordinary tin. The non-allotropic metal investigated was obtained by re-melting the allotropic variety. Both modifications lead to nearly the same specific results.

The indium employed showed itself to be entirely free from tin, cadmium and iron. Oxidized by nitric acid and evaporated with sulphuric acid, it left upon solution in alcohol, no trace of plumbic sulphate. 1·0592 grams of the metal dissolved without loss in nitric acid, gave after evaporation and ignition 1·2825 grams indic oxide. If the latter, according to the previous views, be considered as consisting of equal atoms, there results from this determination the value for the atom of indium, In=37·92, which number agrees very closely with the one determined by Winkler, In=37·81. This atomic weight, multiplied into the obtained specific heat S_c, gives, however, for the atomic heat of indium the value, S_c In=2·13, which does not agree with the others.

The previously accepted hypothesis, that indic oxide is constituted according to the formula InO, appears therefore no longer tenable. If the atomic weight be accepted as once and a half so great, In=56·7, then will the atomic heat be, S_cIn=3·23, nearly equal therefore to that of the other elements. The atomic weight 56·7 removes the anomaly, that indic oxide which was previously considered monacid, is, according to its entire deportment, analogous to that class of trin-acid bases, which forms no alums. For the previously accepted formulæ, given in column I of the following table 8, must therefore be substituted the ones in column II.

TABLE 8.

	I.	II.
Black indious oxide,	InO ?	InO ?
Yellow indic oxide,	InO	In_2O_3
Green indious-indic oxide,	$5InO, In_2O$	$2InO, In_2O_3$
Gray indous-indic oxide,	$4InO, In_2O$	$3InO, 2In_2O_3$
Hydrous indic oxide,	$InO, \text{Ħ}O$	$In_2O_3, 3\text{Ħ}O$
Indic sulphate,	$InO, SO_3. 3\text{Ħ}O$	$In_2O_3, 3SO_3, 9\text{Ħ}O$
Indic chloride,	$In\text{Ȼ}l$	$In_2\text{Ȼ}l_3$
Ammonium indic chloride,	$2\text{NĦ}_4\text{Ȼ}l, 3In\text{Ȼ}l, 2\text{Ħ}O$	$2\text{NĦ}_4\text{Ȼ}l, In_2\text{Ȼ}l_3, 2\text{Ħ}O$

The ammonium-indic-chloride, prepared by R. G. Meyer, and cited in this scheme, possesses, according to the new formula, an analogous composition with ammonium rhodic chloride, which likewise contains 2 atoms of water. Whether or no the altered atomic weight finds comfirmation in an isomorphism in these salts I have been unable to investigate; I shall, however, return to this subject in a research, to be published later, on rubidium.

During this winter, for such experiments very unfavorable, I have been unable to make a trial of the instrument as to its fitness for the determination of the latent heats of melting. I will only mention here that the latent heat of melting for water results already, with an accuracy which leaves nothing to be desired, from the experiments communicated in this work. According to table (2), one scale division of the calorimeter corresponds to $\frac{v\, s_e s_w}{s_w - s_e}$ grams of melted ice. The constant W_w, determined from equation (8), gives the number of scale divisions which correspond to one of the units of heat defined in the beginning of this treatise. One scale division of the colorimeter corresponds therefore to $\frac{1}{W_w}$ units of heat. If l denotes the latent heat of melting for water, then will $\frac{1}{l W_w}$ give the weight of ice, expressed in grams, which corresponds to one scale division. There results, therefore, for l, the equation $l = \frac{s_w - s_e}{W_w s_e s_w\, v}$ or, according to equation (2), $l = \frac{1}{W_w\, p}$.

If the above found values

$$p = 0{\cdot}00085257 \qquad W_w = 14{\cdot}660 \qquad W_w = 14{\cdot}654$$

be substituted in the equation, there is obtained for the latent heat of melting of water l: 80·01
80·04
In the mean, 80·025

The value found by other observers by the method of mixture is, according to Regnault, 79·4; Person, 80·0; Hess, 80·3.

The heat of combustion of gases may be determined by means of the ice calorimeter with far greater accuracy than has been possible with any of the methods previously at our disposal. From the heat of combustion of hydrogen it follows with the aid of equation (4), that 10 cubic centimeters of this gas at 0° C. and 0·76 mercury pressure, would produce by their combustion with oxygen an oscillation of 453 scale divisions on the instrument employed in the experiments just described. It is therefore sufficient to burn a very small quantity of gas, and therefore one easily to be prepared in a state of purity, in the calorimeter, and to observe the oscillation on the scale thereby produced, in order to obtain directly the heat of combustion, expressed in units of heat, without any of the corrections, in part very uncertain, which were previously unavoidable.

ART. LIV.—*On the Geology of the Delta, and the Mudlumps of the Passes of the Mississippi;* by EUG. W. HILGARD.

[Continued from page 246.]

II. *The Lower Delta and the Mudlumps.*

A glance at the map shows that in descending the Mississippi from New Orleans, we find a narrow strip of land only ¾ to 3 miles wide, dividing the river from the waters of the Gulf; from the head of Oyster Bay opposite Pointe à la Hache (about half way between the city and the head of the Passes), down to the mouths. Such, at least, is the case on the left bank; on the right, the "neck" begins a few miles below Fort Jackson. Down to the forts, the aspect of the "Coast" is generally pretty much the same, where its original character has not been lost by cultivation or encroachment of the river. Nearest the river, and highest above water level, are the sandy "willow battures," where the willow, mingled with and occasionally replaced by the cottonwood, forms the predominant growth. Beyond lies a belt of woodland, timbered chiefly with live-oak, magnolia, and cottonwood, often deeply veiled with long-moss; this belt embraces the richest and most durable soils of the "Lower Coast," and is mostly occupied by magnificent plantations of sugar cane and orange orchards. Beyond these, loom in the distance the sombre-hued, moss-curtained denizens of the cypress swamp, their tops forming a level platform sharply defined against the horizon. Between the swamp and the water's edge, seaward, there usually intervenes a zone of reeds, with here and there a stunted cypress, bay, or candleberry bush, where the salt water has but slight access.

While such is the general order of succession of these belts of vegetation where they coëxist, either or both of the two middle ones may locally be absent. Such is always the case where the "neck" is very narrow, as happens below the forts. Thence to the mouths of the passes, the willow batture and the reed marsh alone, with few exceptions, form the barrier between the river and the sea; it is traversed by numerous small bayous, some of which are in great part the work of the duck-hunters that supply the New Orleans market, and whose pursuit leads them to penetrate the marsh for the purpose of reaching the favorite resorts of their game. These bayous increase in frequency as we descend, and in approaching the mouths of the passes, the intervals between them become smaller, until they gradually become sheets of water dividing islands; and finally, just inside the bar, we have the latter resolved into numerous individual "mudlumps," dotting the surface of the sea, on both sides of the main channel.

Sir Charles Lyell remarks (Principles of Geology, 10th ed., p. 448), that the phenomenon of the mudlumps is without parallel, so far as known, in the delta of any other river. The same remark might, I think, appply to two other peculiarities, viz: the protrusion of the long neck of land into the Gulf; and the fact that, after failing to send out any branch of importance for a hundred miles the great river suddenly divides at one point into three widely divergent branches, the middle one of which (the South Pass), forming the direct continuation of the channel, is the smallest, and has long ceased to be navigable. Evidently, a strong extraneous obstacle alone could turn aside the powerful current, and permanently resist its erosive and undermining action. And now, the channel which carries the main current (the Southwest Pass), faithful to the old tradition, is rapidly pushing out into the Gulf its narrow bands of reedy marsh, without a branch of any consequence in ten miles from the head of the Passes to the light-house.

A glance at the coast lines, as well as at the intricate ramifications characterizing the deltas of the Rhine, the Po, the Danube, the Ganges, or the Hoang-Ho; or the broad inlets forming the mouths of the rivers of South America, will show the uniqueness of the Mississippi mouths; the Nile and the Lena alone exhibiting a general form at all analogous, yet very distinct in detail. For the islands off the Lena mouths are not "mudlumps;" and the tongue of land separating Lake Menzaleh from the Damietta branch of the Nile, is a mere sand-bar, exhibiting no analogy save that of form, with the remarkable "necks" of the Mississippi Passes.

It would be fair to infer, à priori, that some connection exists between the exceptional phenomenon of the mudlumps, and the exceptional form of the delta; and that such is really the case, can hardly be doubted upon a candid investigation of the facts. So far from being an unusual phenomenon, *the mudlump-formation appears to constitute the normal mode of progression of the Mississippi mouths;* not only at the present time, but for many ages past; perhaps ever since the broad flood of the Terrace epoch subsided into the present Mississippi.

The characteristic features of the mudlumps have successively been described and discussed by Sidell,* Forshey,† Chase, Beauregard and Latimer,‡ Thomassy§ and Lyell.‖ Yet as the phenomena are nowhere described in their entirety, I will here, as briefly as possible, recapitulate the important points.

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* Report to Capt. Talcott, 1839, in Humphreys and Abbott's Report, App. A.

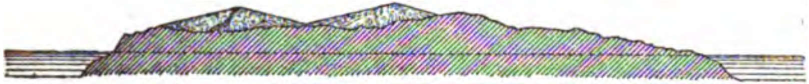
† MS. Report, 1850.

‡ Report of the Board of Engineers for the Examination of the Mississippi; Congress. Doc. 1852–53.

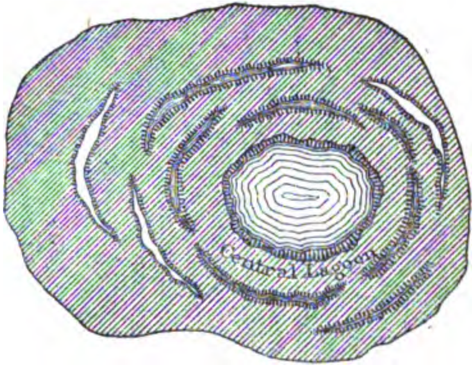
§ Geologie Pratique de la Louisiane, 1860, Chap. VI.

‖ Principles of Geology, 10th edition, 1868; vol. 1, p. 449.

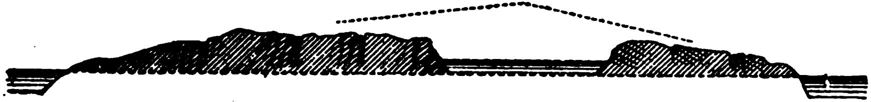
Active Cones.
Salt Spring Island, N.E. Pass.



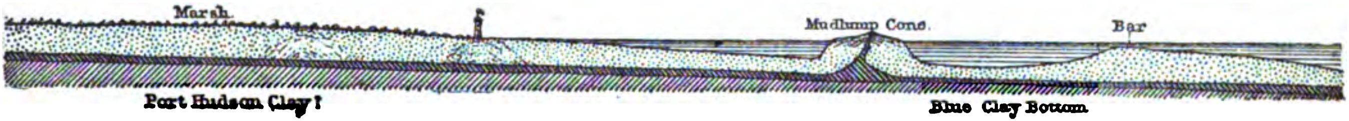
Collapsed Cone
S.W. Pass.



Collapsed Cone, with Central Lagoon.
S.W. Pass.



Origin of Mudlumps.



MUDLUMPS OF THE MISSISSIPPI DELTA.

The mudlumps originate in upheavals of the bottom, in the region lying between the extreme point of the mainland and the crest of the bar, at the main outlets of the passes. They all lie within a distance of from one to three miles from the axis of the main current, and nowhere extend into the bays intervening between the several active mouths. The pilots are under the impression that they form more frequently in the main channel than elsewhere; but allowance must be made for the natural infrequency of their observations outside of the latter; so that only the more obvious and remarkable changes of the bottom, when occurring outside of their regular range, would be likely to come under their notice. *A priori*, it would seem probable that inasmuch as the resistance to the upheaving force, other things being equal, must be less in deep than in shallow water, the lumps would rise more frequently and more rapidly in the channel than elsewhere. On the other hand, the denuding force of the river current must greatly diminish the chances of any such upheaved mass appearing above the surface, or even becoming manifest by a diminution of depth, when progressing slowly. Weighing these considerations against each other, I think a balance remains in favor of the pilot's opinion; the more as concurrent testimony goes to show that whenever the channel is changed, either by the accumulation of deposit or the interference of a mudlump upheaval, the old channel is promptly occupied by mudlumps *throughout* the abandoned portion.

As regards the rapidity of the upheaval, it appears to vary from an almost secular rate, to that of several feet in 24 hours. It has been rumored that lumps had been seen to rise visibly, and burst open like a bubble, but I have been unable to trace the statement to any reliable source, and it is discredited by the pilots. The most rapid rise of which I have obtained reliable information was witnessed by Capt. Andrews, of New Orleans. He states that a steamer having run aground about nightfall inside the bar, her bow being on a mudlump in about 2½ feet of water, he towed her off during the night, and in the morning found the imprint of her bow 18 to 24 inches above water, in the soft mud. Allowing for the possible maximum influence of tides in favor of the difference observed, the minimum rate of upheaval, according to these data, still amounts to one inch per hour. Nor is this the only case in which a rapid shallowing of the water has been observed as a consequence of the grounding of large vessels. This has usually been ascribed to the accumulation of deposit in the slack water so formed, and in many instances this may have been the true cause. But this explanation can hardly apply to the case detailed above, and it is reasonable to suppose that the shock of a grounding vessel may in many cases prove "the hair that breaks the camel's back," when acting upon a portion of bottom just about to yield to the upheaving force, and therefore in a state of unstable equilibrium. Future observations, however, will readily settle the question.

Of authentic observations illustrating ordinary rates of rising, I quote the following remarks of Mr. H. L. Marindin, U. S. Coast Survey, who in 1867, while engaged in the survey of the mouths, at my request paid considerable attention to the phenomena of the mudlumps, and made an interesting report to me on the subject, dated June 20th, and accompanied by specimens.

"Since the first examination of the mudlumps on Southwest Pass Bar, there have appeared numerous lumps in the vicinity of the main channel, whose appearance cannot be attributed to other causes than the upheaval of the bottom by some unknown agency; since tidal observations made during the month of April, May and part of June, show no material decrease in the height of water in the river, other than the daily ebb of the tide. In one instance, also, on this bar, it has been ascertained from surveys made at different times, that where in the month of April a channel with fifteen feet of water existed, there is now a lump, doubtless still forming, with only six feet of water on it at the highest stage."

Making allowance for a possible accumulation of deposit, the rate of rise cannot, in this instance, be estimated at less than two feet per month; which, so long as the lump remains under water, seems to be no unusual amount. When, however, the surface of the water is once reached, the rising becomes slower or ceases altogether, owing probably to the greater weight acquired by the material upon its emergence. At least, I have failed to find much above tide level, any material which did not bear distinct evidence of its having been formed, not by river alluvion, but by the action of the regular mudsprings; which, if not now active upon all the lumps, have demonstrably been instrumental in forming the great majority of the masses now above water level.

I do not know that any one has ever witnessed the first outburst of a mudspring on a newly risen lump; but we find them in all stages of progress, from the islet bearing its first tuft of rushes, to the active cones glistening in the sunshine, and from time to time, when an unusually large gas bubble rises, spattering the liquid mud (which usually flows in a quiet stream) all over the slopes; then the half-extinct cone, in whose crater a little pool of salt water is at long intervals agitated by a gas bubble; then the extinct and collapsed cone, surrounded by a circular moat and Somma-like ring-wall; next, the old lump of jagged outlines, whose disintegrated materials are rapidly yielding to the combined attack of rain, sunshine and waves, till something looking like a large stump of a tree is all that remains of an island of several acres; and finally the shoal, marked by dangerous rollers, whose surface, on a calm day, still exhibits the concentric markings corresponding to the several cones which originally built up the island.

I regret being unable at the present time, to present accurate sketches of these several stages of "the mudlumps' progress." I hope to do so hereafter, but for the present must confine myself to the approximate outline representations given in the plate, and a brief description of the several stages as observed by myself in 1857.

Nascent Lumps.—As regards the first, it is probable that a good many lumps never pass beyond that stage of development, for the reason that, so soon as the resistance is materially increased by the emergence of a portion above the surface of the water, the upheaving force seeks a vent elsewhere.

Either the mud or gas-spring breaks out beneath the water, and becomes perceptible only by the more or less regular and localized evolution of bubbles on the outskirts of the lumps; a very common phenomenon in the neighborhood, not only of new and active lumps, but also about extinct ones, which are in course of demolition by the waves. On the extensive sandy shoal off Stake Island, on the Southwest Pass, such subaqueous gas-springs may be observed in great numbers.—Or it may happen, that another portion of the bottom, now offering less resistance than the mudlump, will, in its turn, give way before the upheaving force, till the same degree of emersion is obtained, or a vent is opened.

I have been unable to ascertain how high any mudlumps can rise bodily above the water without the appearance of a vent. As much as three feet has been observed with certainty; but unless the fact that it is a new upheaval be historically known, it must be extremely difficult to ascertain it, unless, by actual access to the interior, it can be shown that its surface strata are old river deposits, which can readily be distinguished from those formed by mudlump vents. Yet these might, during the elevation of the lump, have been removed by the current. At all events, I have failed to find on the surface of any lump much above tide-water, anything like true river alluvium; the visible material being either such as is now formed by active vents, or, (as on the lower slopes), that which obviously results from the disintegration of the former, being altogether devoid of structure.

It is said that lumps sometimes sink from view again after bare emergence. I know of no authentic example, but it seems likely enough that upon the formation of a large vent elsewhere, such a thing might happen; especially if, as I think probable, mudsprings and mud-cones form *beneath*, as well as above the water.

Active Cones.—In the second stage, that characterized by the formation of the active eruptive cones, mudlumps offer an aspect so strikingly like that of the mud volcanoes of Tuscany, as to stagger the observer's geographical consciousness. The most striking example of the kind existed, at the time of my visit, off Pass à l'Outre, on the south (right) side of the channel. The island* is about an acre in extent, and besides the active vents (of which there are seven), we perceive on the southern portion the remnants of long extinct craters, in various degrees of advancement toward old age and degradation, and partially covered with vegetation.

The cones on the north or channel side, at a distance, present a glistening surface, and those possessing a central vent only are very regularly and smoothly conical. Of these there are four, the diameters of the bases ranging from eighteen to fifty feet, and their elevation from one to two and a half feet above the general level of the island; making the angle of the slope from 5° to 8° only, instead of 25° to 35°, as given in the published sketches. I have seen no undisturbed cone whose slope exceeded about 12°. The slope is, of course, essentially a function of the thickness and character of the mud; which in the present instance flows from the circular basin at the summit, 4 to 8 ins. in diameter, in a regular, creamy stream, interrupted occasionally only by a gas bubble; which, if the mud be thick, spatters it about to some extent. The mud-stream varies from 3 to 4 gallons per minute in the largest (eastern) cone, to a pint or two in the less active ones; sometimes, in running down the sides, it spreads over as much as $\frac{1}{8}$ of the circumference, but usually forms a stream 4 to 8 inches wide, serpenting down the slope between banks formed by its own solidification, as does a lava stream. As these banks grow in height by drying, on the edge of the crater, they gradually compel the mud to rise higher before it can flow off; whereupon, after a while the column overflows at another point of the circumference, where the same play is then repeated. In the meantime, the previous mudstream has an opportunity of consolidating, drying more or less, and undergoing a variety of chemical changes dependent upon the character of the water and the duration of the exposure to the air, which manifest themselves in changes of color and consistency; by these the individual streams are distinctly defined from one another. Each one forms, of course, a more or less irregular portion of a conic surface, the cross section being more or less lenticular.

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* It was named Marindin's Lump by the crew of the U. S. Coast Survey Schr. Varina, and I shall allude to it under that designation.

There results, as may be supposed, a very peculiar structure or stratification, unlike anything usually seen outside of volcanic districts, unless, perhaps in the somewhat analogous case of the lee side of dunes. It may roughly be compared to the upper half of an onion. It is needless to say that, once seen, it cannot readily be mistaken for anything else; and its absence must be held as proof conclusive of an absence of genetic analogy.* The thickness of the layers rarely exceeds 1½ inches; their colors vary from dark mouse-color and bluish gray, through dun and buff, to rust-color and red; the materials, from hard, plastic clay, always containing a great deal of fine silex and more or less coarse sand, to sandy clay and, rarely, clayey sand; the selvedges are frequently marked by iron rust and mica scales. Where, as is frequently the case, neighboring cones are confluent at their bases, the structure is of course complicated in a manner readily imagined.

As regards the gas evolved (which is in all cases inflammable), the small proportion its bulk bears to that of the mud simultaneously ejected (about $\frac{1}{25}$ to $\frac{1}{30}$ at Marindin's Lump), at once does away with the impression mostly entertained, that the gas bubbles bring up the mud with them. The latter comes up with a steady flow, evidently the result of static pressure, and is only from time to time agitated by a gas bubble, larger or smaller according as the mud is more or less consistent. We sometimes find, about extinct cones especially, lively gas springs in which the proportion of gas is considerably greater, than happens in any active cone that has come under my observation; but in that case, it is almost always accompanied only by *water*, as though its source were above the stratum which furnishes the mud. For, a glance at the river deposits forming around the lumps, at once shows that they are totally different from the fine, clayey material of which the cones are formed; nor is it credible that the mere passage of a current of water and gas through such deposits, or in fact, *any consolidated materials*, should produce such a perfect, creamy mixture as that ejected from these craters.

Extinct Cones.—Good examples of cones whose activity has nearly or quite ceased, may be seen off the Northeast Pass. Here the material is somewhat sandier and firmer than the mud ejected at Passe à l'Outre. While at the latter place it was difficult to reach the craters without being hopelessly bogged, they can readily be reached almost dry shod at the Northeast Pass. Here, also, the top layers were peeling off in large concave "flakes," from the effect of sun-cracks and drying; such a surface again overflowed by mud would add another singular feature to the structure of the cones, which may also be noticed in many sections of ancient ones.

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* Vide Thomassy's remarks on the Five Islands, etc., Géol. prat. de la Louisiane, chap. viii. With even less show of reason, a similar origin has repeatedly been claimed for the low circular mounds which dot a large part of western Louisiana. They consist exclusively of unstratified sandy materials, and are doubtless the result of animal activity—probably of the large ant.

The vent of a large cone in this region (see Plate) formed a basin about 8 inches diameter, containing a puddle of salt water covered with an iridescent ferruginous pellicle, disturbed at long intervals by small gas bubbles. Evidently, the resistance in the large cone, elevated about 10 feet above the water level, had become too great for the ejection of mud; in consequence whereof, a lively little cone was glistening and bubbling at a level several feet lower, near the foot of the old cone. *But the testimony of the pilots goes distinctly to show, that the active cones become more lively, and dormant cones resume their activity, at high stages of water in the river.* At the time of my visit, the water was at an unusually low stage.

Collapsed Cones.—The cones, especially the larger ones, appear to be unable to survive for any great length of time the cessation of activity. The change that occurs seems to be, in all cases, a sinking of the central portion, often to such an extent that its place becomes occupied by a pool or lagoon, surrounded by a circular rim whose strata incline *away* from the center at angles invariably much steeper than is found in any recent cones, from 20° to as much as 45°. Outside of this first rim there mostly appears a series of concentric crevasses, sometimes several feet in width and in depth; and the annular segments thus brought to a level by a subsidence, also exhibit the singular feature of a *steeper* inclination of the lines of deposition, than is found in any cones now forming. The seeming anomaly of this fact caused me to observe the phenomena closely; but I have been unable to find an exception to the rule; and I have been led to doubt whether in some cases, instead of true eruption cones, these collapsed areas and their surroundings may not be the remnants of the original upheaved "bubble." The objection to this interpretation is the character of the material, which, excepting in a few cases on the Southwest Pass, is altogether unlike the present river deposits, both in structure and composition.

A most perfect exemplification of a large central lagoon (100 feet by 75) surrounded by an elevated rim and several successive, concentric "moats," also in part filled with water, occurs on one of the numerous mudlumps S.W. of Stake Island, on the Southwest Pass (see Plate). The central portion does not always, however, sink out of sight; sometimes a conical mound is still observable, as the center of the more or less circular, concentric crevasses, which a close inspection shows to exist on almost all lumps not too far advanced towards decrepitude. Many islands exhibit several such centers and systems of crevasses, indicating, probably, the previous existence of cones, sometimes several hundred feet in diameter, greatly exceeding the largest now in a state of activity, both in diameter and original height.

Degradation and Disappearance of Lumps.—The direct action of the waves, unassisted by atmospheric agencies, produces but little effect upon the yielding, but tough and coherent material of the cones. The heaviest breakers and rollers spend their force in vain against the clay shoals which render most of the lumps so difficult of access. The unwary will often be tempted by the deceptive, rock-like aspect of this material, to jump into the shallow water and wade ashore; but a plunge knee-deep into the apparent solid will frequently reward his temerity. Yet so long as this mass, which shows plainly the peculiar, concentrically banded mudlump structure, remains constantly covered with water, the waves rolling over it produce but little impression.

Not so with the portion that projects above water, which is alternately exposed to rain, sunshine, and the wash of waves. Especially where the material is clayey, these agencies combined soon produce a change in which the structural as well as the paleontological characters of the original material are totally obliterated. A rain falling upon a fresh surface of the latter, causes it to swell; then, upon exposure to sunshine, it will contract into prismatic cleavage-forms. A slight rain, or the spray itself, will then cause the extreme surface to crumble into, and partially fill up, the cracks; when the swelling consequent upon a thorough wetting, by either rain or waves, will force them to open still more, while streamlets of fluid mud follow each retiring wave; which, perhaps, has thrown up, and left high and dry in the cracks, a dozen species of shells, entirely foreign to the mudlump mud itself. It is thus that the structureless, tough soil of the general surface, and of the beach of the mudlumps, is formed; and to it alone apply the descriptions given of the mass of the mudlumps, by Sidell, Thomassy and Lyell, as a "homogeneous, tenacious mud."

A frequent repetition of this process involves, of course, not only a rapid direct degradation of the lump, but it causes it to be cleft into fragments by rents gradually progressing from above downward, which rapidly increase the surface exposed to attack; and eventually, some large wave, in retiring, carries down with it a huge prismatic slice, leaving behind an almost vertical cliff. This is carried away in its turn, and thus, attacked from all sides, an island of considerable size, after passing through a variety of middle stages in which it strikingly resembles masses of trap or basalt, magnified into distant mountains by the peculiar optical delusion prevailing in the region,* is finally reduced to what, at a distance, appears to be the stump of a tree. At last, some storm sweeps away this last monument of the disappearing lump, and white-capped rollers alone mark, thereafter, the higher points of the mud-shoal.

I have best observed these phenomena of disintegration in every stage of progress, among the mudlumps off the Northeast Pass, where the fanciful, cliff-like forms, figured by Thomassy, Sidell, and Lyell, may be seen to perfection.

It is said that there are no mudlumps off South Pass or Grand Bayou; a statement which may require to be taken with a grain of allowance, but agrees with the general impression that the mouths discharging the largest amount of water, also exhibit mudlump activity on the most extensive scale.

The Southwest Pass is the main outlet at the present time; the area inside the bar is thickly studded with mudlumps, chiefly west of the channel; and as before stated, lumps have risen there repeatedly under the eyes of the pilots and survey parties. Yet there is not there, at the present time, a single *active* cone, so far as I am aware; although salt water and gas springs are of frequent occurrence, both on and around the islands. There is a marked difference between the river deposits as well as the mudlump materials of Passe à l'Outre and Southwest Pass, the latter being decidedly more sandy, and sand bars taking the place of the mud flats off the former. Whether this circumstance (the natural result of the greater swiftness of the current in Southwest Pass), is connected with the absence of active cones, it may be too early to discuss. Some very lively springs on a large mudlump off Stake Island on that Pass, in which the gas emitted is about equal in bulk to the water, rise in small basins excavated at the foot of a large cone which must have been 15 to 18 ft. high; but the material they bring up is so very sandy that the water runs off perfectly clear.†

Mudlumps in the Marshes.—I have before remarked, that at the present time, the upheaval of mudlumps on the passes, and subsequent silting up of the shallows between them (by river deposit, as well as by the degradation of the lumps themselves,) seems to be the normal mode of progression of the delta. The more advanced portions of the narrow bands of shore now forming along each one of the passes, are historically known to consist of mudlump-chains; and in the absence of any plausible presumption to the contrary, as well as of any parallel example in other rivers, it is reasonable to surmise, that not only the shores of the present passes, but also the neck, *at least* from Pointe à la Hache down, owes it formation and peculiar features to the same agencies.

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* Caused probably by a faint bluish haze, through which an island a quarter of a mile distant and 15 feet high, appears to be a wooded mountain with rocky escarpments, and at its foot a wide spreading city—which suddenly resolves itself into a row of grave white pelicans perched on the beach and taking wing at the approach of a boat.

† See analysis of the water of these springs, below; marked "S. W. Pass, I."

We have seen how rapidly and completely the joint action of the waves and atmospheric agencies accomplish the degradation of elevated lumps to the common level of the tide; and where the nature of the materials is such as to yield readily to these destructive influences, it would be unreasonable to look for vestiges of ancient lumps above that level. Such is the case, as before mentioned, on Northeast Pass and its branches.* But the sandier nature of the mudlump mass on Southwest Pass enables it to resist much longer, so that some of the larger and more elevated islands there seem destined to retain, more or less permanently, their present form. For the same reason, perhaps, the Southwest Pass furnishes the one prominent example of the existence of an active and characteristic mudlump, in the level marsh on the right of the channel, about five miles below the Head of the Passes, and seven above the mouth (light-house); distant 1½ miles from the river bank, and about one mile from the beach of West Bay. Double-headed Bayou, or one of its channels, passes within a few hundred yards of this lump; which is so difficult of access that it has been very rarely visited, though plainly visible from the hurricane deck of passing steamers, from which I have examined it with the telescope.

According to Thomassy,† the pilot Ben. Morgan, who has visited it, describes it as being "a regular truncated cone, 20 to 25 feet high and 300 in circumference, spouting at intervals from its summit masses of clayey and sandy mud, which overflows all around."

From the Pass, it now appears as a slightly irregular, conical hill, which, judging from the extent to which it projects above the highest reeds, is about 18 to 20 feet high at most. On its eastern side there is a second cone about half as high, with a very regular slope not exceeding 30°, while that of the large one is at least 45°. A whitish sheen which extends from the summit of the larger cone toward the smaller one, I interpret as a white salty efflorescence; but on the south slope of the smaller cone, the glittering of a flowing mudstream was unmistakable. Inasmuch as in Morgan's account of his visit the smaller cone is not mentioned, it is presumable that it has been formed since, by a lateral eruption; the old cone having, perhaps, reached the extreme limit of height to which mudlump force can raise its materials.

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* Col. Sidell mentions a mudlump cone, 18 feet high, on the north side of the Northeast Pass, in the marsh. It has probably succumbed since his visit, as in passing the spot I was unable to perceive any elevation, nor was it known to the pilots.

† Géol. prat. de la Louisiane, p. 56. I shall designate this cone as "Morgan's Lump."

The steep slopes of both the old and new cone are suggestive as to the influence of sandiness on that feature, and the explanation of the steep inclination of strata, observed chiefly on Southwest Pass.

It is my impression that another cone exists in the marsh about two miles south of these. It is almost screened from view by the reeds, but the telescope shows it to be distinctly conical. It does not seem to have attracted notice heretofore.

But if mudlump cones are scarce in the marshes, the same is not true with reference to the salt and gas springs, which are reported to be quite abundant by the hunters—the only men whose occupation leads them to "thread the pathless waste" of reedy marsh, otherwise seldom visited, save by surveying parties, and alligators. These springs are found on or around all mudlumps, of whatever age; even on the shoals left behind by disintegrated lumps, where they issue under water, sometimes altering perceptibly the character of the water in the immediate neighborhood. The Southwest lighthouse was originally built on a mudlump separated from the mainland by a bayou; this is now filled up, but salt springs still issue at several points in the marsh near the foot of the tower. It is obvious that the gradual accumulation of deposit is not likely to check lively springs, possessing sufficient head to rise, hydrostatically, above the level of the alluvium; though in many cases they may lose themselves in the sandy strata.

I have not had an opportunity of ascertaining whether or not salt springs are known to exist in the marshes near the Forts, and above. I fully expect to find, however, that they do exist, though, for obvious reasons, they will become less and less abundant as we ascend the river. At New Orleans, as already stated, gas and salt water are reached, and brought to the surface with considerable vehemence, by bores varying from 31 to 56 feet;* and I have no difficulty in believing in the correctness of the impression made upon Col. Sidell, that the foundations of the New Orleans customhouse were located upon a mudlump.† That such obstinate resistance as that of the "Head of the Passes" to denudation can hardly be attributed to a mass of river deposit, I have already intimated. A large mudlump mass has, probably, first caused the deflection.

[To be continued.]

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* See above, p. 245.

† Lyell's Principles of Geol., 10th ed., p. 552.

ART. LV.—*On the existence of the (so-called) compound Ammonium Amalgams;* by the late CHARLES M. WETHERILL, PH.D., M.D.

THE discoverer of methylamine did not succeed in forming a compound analogous to the ammonium amalgam, whether by the reaction of methyl ammonium chlorid with potassium amalgam, or by the influence of the galvanic current. This experiment, with negative results of Wurtz, is quoted in nearly all of the descriptions of the compound ammoniums.

In a series of experiments (this Journal, II, vol. xl, Sept., 1865) upon the formation and nature of the ammonium amalgam, by which it was demonstrated that this body is merely a metallic froth, I succeeded in forming the so-called amalgam of methyl ammonium. This body was found to be of a nature essentially similar to that of the ammonium amalgam, but of less turgescence. The salt used was the methyl ammonium oxalate, which was compared in this reaction with the ammonium oxalate. MM. Pfeil and Leffman (this Journal, II, vol. xlii, p. 72) repeated these experiments and confirmed the results, employing the tri-methyl ammonium chlorid. They also extended the reaction with sodium amalgam to the chlorohydrates of aniline, coniine, morphine and quinine and to the acetate of rosaniline; but without forming amalgams, hydrogen gas being evolved copiously without swelling.

H. Landolt (VI supplement, Annalen der Ch. u. Pharm., p. 346, "Ueber das ammonium amalgam") states in a foot-note, that he had repeated the experiment with tri-methylamine chlorid and sodium amalgam, and found "that the turgescence of the mercury takes place only when the preparation contains ammonium chlorid; the pure compound gives no amalgam.

This rendered necessary a repetition of my experiment upon the compound ammonium amalgam, as I had not myself tested the salts employed with respect to their purity. The former experiments were performed with a pure methyl ammonium oxalate, for which I am indebted to the kindness of M. Carey Lea, Esq., who gave me some prepared by his new method, being the same described by him in this Journal, vol. xxxiii, p. 366.

In the present experiments I prepared a fresh portion of the methyl ammonium oxalate by Lea's process, viz: by the action of aqua ammonia upon methyl nitrate. The two liquids were placed aside in a stoppered bottle for ten days, by which time the ether had disappeared. The distillate of this liquid over caustic potassa was exactly neutralized by oxalic acid and evaporated to crystallization. After removing the ammonium oxalate, the mother water was evaporated to dryness and boiled with 95 per cent alcohol; the hot filtrate on cooling yielded nacreous scales of methyl ammonium oxalate. The mother water of these crystals, by concentration, furnished an additional quantity a little darker in color. By filtering the crystals and washing them with 95 per cent alcohol by the aid of the Bunsen filter pump, they were completely freed from the dark mother water in which they formed. As the quantity of salt at my disposal was not more than a gram, fearing to reduce it by a recrystallization, I first tested the effect of a solution of the crystals upon sodium amalgam, and then converted a portion of each cup to methyl ammonium oxalate in which the Pt was determined. All which remained of the oxalate was recrystallized from a hot solution of alcohol and ether and experimented with, as in the former case. The crystals appeared to the naked eye to be prisms, but the microscope demonstrated them to be feathery needles polarizing light. They were very electric when warm, and possessed the property of felting together when pressed by the finger. They yielded golden-yellow crystalline scales or plates when converted into the Pt salt This salt is much more soluble than the corresponding ammonium salt, and crystallizes again from its solution in golden yellow hexagonal and triangular scales, being part of the octahedron and its replacements. The following are the results of the different analyses, from which it may be perceived that the methyl ammonium oxalate is perfectly pure, and that, as stated by M. Carey Lea, the first crystallization of the oxalate is pure.

I noted with respect to the Pt salt that some crystallizations furnished scales of a reddish tinge, but which gave the same percentage of platinum as the golden-yellow scales. The small quantity of substance at disposal for the analysis required very careful weighing to ¼ of a milligram.

Analysis of methylam. chloroplatinates from methylam. oxalates.

	Grms. taken.	Grms. Pt.	Per cent Pt.*
First cryst: darker oxalate,	0·4155	0·172	41·40
Repeat,	0·43975	0·18325	41·67
First cryst: lighter oxalate,	0·345	0·1435	41·59
Ditto recrystallized,	0·13675	0·05675	41·50
Chloroplatinate from mother-water of the last chloroplatinate,	0·0655	0·027	41·30
Mean of all the analyses,			41·49
Wurtz's analysis,			41·40
Theoretical per cent,			41·59
Ditto for ammonium salt,			44·29

These different specimens of methyl ammonium oxalate, dissolved in water, gave similar results when shaken with sodium amalgam. To ascertain this fact, a portion of fluid sodium amalgam of the size of a pea was placed in a small test tube ($\frac{1}{2}$ inch diam.), and the solution of ammonium oxalate added, the swelling was observed both with and without shaking, in the cold and with warming. The same experiment was performed with the different specimens of methyl ammonium oxalate. The latter all swelled to from 8 to 10 times the original volume, which was very much less than the turgescence of the ammonium salt. With the compound ammonium salt, the swelling was not apparent until the tube was shaken and heat facilitated the reaction; this may be the reason that it has been hitherto overlooked. The methyl ammonium amalgam presented the same buttery appearance as the ammonium amalgam, and a knife blade placed in it was amalgamated. When the lump was pressed between two plates of glass, as in the method I proposed, to prove the frothy nature of the so-called ammonium amalgam, myriads of gas bubbles were apparent; when these were pressed out the amalgam was at once restored to the condition of mercury. In all cases shaking the tube appeared to be necessary in order to develop the swelling to its *fullest* extent. In performing this act, care was taken not to convey the ammonium salt to the methyl ammonium tube by the finger.

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* Eq. Pt 1·98.

In the former experiments it was not deemed necessary to form the compound ammonium amalgam by the aid of the battery; in the present this result was attained in the following manner, (vide op. cit., Exp. 15).

A piece of filter paper was placed upon a glass plate, then saturated with a strong solution of the recrystallized methyl ammonium oxalate. A globule of mercury of the size of a small pea was placed upon the paper with the negative pole of 20 cells Bunsen in contact with it; the positive pole touching the paper. The globule swelled slightly, presented a buttery appearance, attached itself to and amalgamated the blade of a penknife which was in contact with the negative pole, and upon being pressed under a glass plate *showed innumerable gas bubbles in its substance*, (in fact was a metallic froth) which emitted an ammoniacal odor.

It results from these experiments that the compound ammonias (at least that which I have examined) may form the so-called amalgam. I defer the bearing which this fact has upon the so-called ammonium and hydrogenium amalgam to a paper of some experiments which will shortly be published.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the spectrum of the Aurora Borealis.*—**Zöllner** has called attention to the fact already remarked by other observers that the lines in the spectrum of the aurora borealis do not coincide with those of any known element, and has endeavored to give a rational explanation of the want of coincidence without assuming the presence of unknown elements in the earth's atmosphere. If the lines in question are really of electrical nature and are produced by the ignition of highly rarefied gases, the ignition must take place at so low a temperature that it would be impossible to observe the lines in Geissler's tubes. Hence Zöllner thinks that the spectrum of the aurora does not correspond with any known spectrum of the atmospheric gases, because it is a spectrum of a different order which cannot at present be produced artificially. If, at a given temperature, $A\lambda$ and $E\lambda$ represent respectively the values of the absorptive and emissive powers for the wave length λ for the unit of thickness and density, m and σ the thickness and density of the luminous layer of gas, we have, according to Zöllner, for the brightness E of the part of the spectrum corresponding to λ, the expression

$$E = [1 - (1 - A\lambda)^{m\sigma}]\frac{E\lambda}{A\lambda}.$$

For a given gas and given temperature this expression depends only on the value of the product $m\,\sigma$. In a Geissler's tube filled with rarefied air, take the diameter of the narrow part of the tube as 1^{mm}, and regard this as the unit of thickness m, and take as the unit of density the density of the enclosed air corresponding to a temperature of 0° and pressure of 1^{mm} of mercury. If now we ignite the air in the tube by an inductorium, then at a constant temperature the spectrum would remain qualitatively and quantitatively unchanged if the diameter of the narrow tube were increased from 1^{mm} to 1000^{mm}, and if at the same time the pressure on the gas were diminished to $\frac{1}{1000}{}^{\mathrm{mm}}$.

Wüllner found that in the case of nitrogen the spectrum became sufficiently luminous for spectroscopic examination only when the pressure was diminished to 46^{mm}, while in the case of oxygen the necessary diminution was to 28 to 30^{mm}. If we assume that in Wüllner's apparatus the current passing through a tube 1^{mm} in thickness and under a pressure of 50^{mm} produces light enough to observe the atmospheric spectrum, we may compare with this the thicknesses of the luminous layers which occur in the case of the aurora, which are of course far greater, and, at a distance from the zenith, to be estimated in miles. If we take the thickness of such a layer as only 1 kilometer, then at the same temperature as in the last case, the density would have to be only the one-millionth of that of the air enclosed in the tube, and therefore exert a pressure of only $0{\cdot}00005^{\mathrm{mm}}$ at 0° C., in order that the spectrum of the air in the tube should completely correspond with that of the aurora. The question then arises—is it permissible to assume the existence of such low degrees of pressure in the regions of our atmosphere in which the aurora is developed? If we suppose the aurora to be at a height of ten geographical miles, the temperature of the atmosphere at the surface of the earth being 0° and the barometric pressure 760^{mm}, the pressure will be $0{\cdot}078^{mm}$; at a height of twenty miles, $0{\cdot}00001^{mm}$. A layer of ignited air 1^{m} in thickness would therefore, at a height of ten miles, be equivalent to a pressure of 78^{mm}, and at a height of twenty miles, to a pressure of $0{\cdot}01^{mm}$ in a Geissler's tube, in order at the same temperature to give a spectrum as bright as that of the autora. But as the thickness of the layer of ignited air must be reckoned by kilometers instead of meters, we should have, even at a height of ten miles, so high a value for the equivalent pressure in a Geissler's tube—78^{m} of mercury for a layer 1 kilometer in thickness—that the most powerful induction apparatus could not overcome the resistance of the air. From this it follows that the quantity of particles of ignited air in a Geissler's tube is probably extremely small when compared with the *active* quantity in the case of the aurora. Since, however, the spectrum of a gas in such a tube must have at least the brightness of the auroral spectrum to admit of spectroscopic analysis, it follows that the emissive power of the particles of gas ignited in the tube must be much greater than that of the ignited gaseous particles in the case of the aurora. Such a difference can be produced *only* by differences in temperature. If, therefore, the light of the aurora depends on ignited particles of our atmosphere, the temperature at which the ignition takes place must be much lower than that at which the same gases can be ignited by electricity in Geissler's tubes. From these considerations it appears that all the gas-spectra of the different orders which we can artificially produce belong in general only to high temperatures, since the relatively greater brightness with less quantities of ignited matter renders a greater emissive power necessary, and this can be produced only by a higher temperature. Conversely as in the case of the aurora, corona, zodiacal light, &c., a great number of active luminous particles must be assumed to exist, it follows that the temperature of the ignited gases must be relatively low.—*Pogg. Ann.*, cxli, 574. W. G.

2. *Synthesis of coniin.*—By the action of an alcoholic solution of ammonia upon butyric aldehyd, at a temperature not exceeding 100° C., Schiff obtained two bases, the formation of which may be represented by the following equation:

$$\underset{\text{Tetrabutyraldin.}}{\text{Є}_{16}H_{29}N\Theta}=4\text{Є}_4H_8\Theta+NH_3-3\Theta H_2$$

$$\underset{\text{Dibutyraldin.}}{\text{Є}_8H_{17}N\Theta}=2\text{Є}_4H_8\Theta+NH_3-\Theta H_2$$

By the distillation of dibutyraldin, besides oily substances and bases of a higher order of condensation, a strong alkaline base is obtained which possesses all the properties of coniin, the formation of which may be represented by the equation:

$$\underset{\text{Dibutyraldin.}}{\text{€}_8H_{17}N\Theta}=\Theta H_2+\underset{\text{Coniin.}}{\text{€}_8H_{15}N}$$

According to this synthesis, the structural formula of coniin would be:

$$\begin{array}{l}\text{€}H-\text{€}H_2-\text{€}H_2-\text{€}H_3\\ \vert\\ \text{€}H-\text{€}H_2-\text{€}H_2-\text{€}H=NH\end{array}$$

The author promises further details.—*Berichte der Deutschen chem. Gesellschaft, Jahrgang* iii, p. 946. W. G.

3. *On the basicity of uranic oxide, molybdic, boric and nitrous acids.*—SCHULTZ-SELLACK has found that the normal sulphates of antimony and bismuth may be easily prepared in an anhydrous state, by dissolving the oxide in moderately concentrated sulphuric acid and evaporating. Both salts crystallize in fine needles; they are respectively $Sb_2(\text{Ꞩ}\Theta_4)_3$ and $Bi_2(\text{Ꞩ}\Theta_4)_3$. On the other hand, uranic oxide, molybdic, boric and nitrous acids form analogous compounds, the formulas of which are:

$$\begin{array}{lll}(\text{Ʉ}\Theta)_2\text{Ꞩ}\Theta_4, & (HU\Theta)S\Theta_4, & (\text{Ʉ}\Theta)_2\text{Ꞩ}\Theta_4+\text{Ꞩ}\Theta_3\\ (M\Theta)_2\text{Ꞩ}\Theta_4, & & \\ & (HN\Theta)\text{Ꞩ}\Theta_4, & (N\Theta)_2\text{Ꞩ}\Theta_4+\text{Ꞩ}\Theta_3\\ & & (HB\Theta)_2\text{Ꞩ}\Theta_4+\text{Ꞩ}\Theta_3.\end{array}$$

The uranic and molybdic salts are crystalline; the boric salt is a thick fluid or glassy mass, which could not be obtained of constant composition. The analogy between some of the above salts and potassic dichromate is easily seen, when the formulas are written $(\text{Ʉ}\Theta)_2\text{Ꞩ}_2\Theta_7$, $(N\Theta)_2\text{Ꞩ}_2\Theta_7$, $(HB\Theta)_2\text{Ꞩ}_2\Theta_7$. In a subsequent paper the author describes several other compounds of analogous constitution, which may be derived from the acid $H_2\text{Ꞩ}_2\Theta_7$, and some of which are new. The salt $KH\text{Ꞩ}_2\Theta_7$ may be obtained crystallized by dissolving $K_2\text{Ꞩ}_2\Theta_7$ in fuming sulphuric acid. It crystallizes in prisms which fuse at 168° C. The silver and barium salts have respectively the formulas $Ag_2\text{Ꞩ}_2\Theta_7$ and $Ba\text{Ꞩ}_2\Theta_7$. The salts of arsenous and antimonous oxide, $As_2(\text{Ꞩ}\Theta_4)_3+\text{Ꞩ}\Theta_3$ and $\text{Ꞩ}b_2(\text{Ꞩ}\Theta_4)_3+\text{Ꞩ}\Theta_3$, or, as we should prefer to write them, $As_2\Theta(\text{Ꞩ}_2\Theta_7)_2$ and $\text{Ꞩ}b_2\Theta(\text{Ꞩ}_2\Theta_7)_2$, are both crystalline and easily decomposed by water.—*Berichte der Deutschen chem. Gesellschaft*, iv *Jahrgang*, p. 12 and 114. W. G.

4. *Researches on Vanadium.*—ROSCOE has communicated to the Royal Society a further instalment of his very valuable and interesting researches on vanadium. Metallic vanadium absorbs hydrogen in quantities which vary according to the state of division of the chloride from which the metal is prepared (VCl_2) and of the metallic powder itself. When the compound is exposed to dry air it takes up oxygen, forming water and an oxide which has nearly the formula $V_2\Theta$.

Vanadic oxytribromide, $V\Theta Br_3$, is formed by passing the vapor of bromine over vanadic trioxide, $V_2\Theta_3$, heated to redness. It is a dark-red transparent liquid, which under a pressure of 100^{mm} of mercury volatilizes between 130° C. and 136° C. Its density at 0° C. is 2·9673.

Vanadic oxydibromide, $V\Theta Br_2$, is formed when the oxytribromide is heated above 180° C. It is a very deliquescent yellowish-brown solid resembling ochre. Heated in air it loses bromine and yields the pentoxide.

Vanadic tribromide, VBr_3, is a grayish-black opaque amorphous sublimate formed by passing dry bromine vapor over vanadic nitride heated to redness. It loses bromine on exposure to the air, and is very deliquescent.

Vanadates.—Roscoe finds that there are three classes of vanadates which may be termed metavanadates, pyrovanadates and orthovanadates. Sodic orthovanadate is formed by fusing vanadic pentoxide with sodic carbonate, dissolving in water and precipitating with alcohol. Its formula is $V\Theta_4Na_3+16\Theta H_2$. It is extremely unstable, being readily decomposed according to the equation:

$$2(V\Theta_4Na_3)+\Theta H_2=V_2\Theta_7Na_4+2NaH\Theta.$$

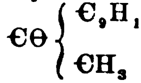
The orthovanadates are mostly insoluble compounds. Pyrovanadate of sodium has the formula $V_2\Theta_7Na_4+18\Theta H_2$, and is crystalline and easily soluble in water. When heated with carbonic dioxide it yields sodic carbonate and metavanadate:

$$V_2\Theta_7Na_4+\text{Ȼ}\Theta_2=2V\Theta_3Na+\text{Ȼ}\Theta_3Na_2.$$

The author describes various salts of vanadic acid, and points out the fact that the order of stability is at ordinary temperatures, first, metavanadates, second, pyrovanadates, and third, orthovanadates, which is exactly the reverse of the order in the case of the phosphates.—*Journal of Chem. Society*, vol. ix, p. 23. W. G.

5. *On a new platinum chloride.*—SIDNEY A. NORTON has given a preliminary notice of a new chloride of platinum, discovered by him in Prof. Kolbe's laboratory. If one molecule of platinic chloride be mixed in aqueous solution with two molecules of silver nitrate, the yellow compound of platinous chloride with silver chloride $PtCl_2$, AgCl, described by A. Cammeille (C. R., lxiii, 553) is thrown down. The yellowish-red liquid above contains no silver; on evaporation, it evolves acid vapors abundantly, and when sufficiently concentrated, deposits on standing over sulphuric acid, beautiful large well-formed red crystals, which appear to be monoclinic in form. These crystals contain only platinum and chlorine—in the proportions of platinic chloride—and water. They are distinguishable from the ordinary platinic chloride by being non-deliquescent in the air—even slightly efflorescing in dry air—and by the fact that their aqueous solution is not precipitable by ammonium chloride, until after long standing or on the application of heat. Norton suggests that this compound may be a hydrated platinic-oxide hydrochlorate, $Pt\Theta_2$, 4HCl, aq. or a chlor-platinic oxide hydrochlorate $(PtCl_2)O$, 2HCl, aq. isomeric with the ordinary hydrated chloride. Investigations now in progress will settle the

point for this as well as for other similar metallic compounds.—*J. pr. Ch.*, II, ii, 469, Dec. 1870. G. F. B.

6. *Synthesis of Oil of Rue.*—GORUP-BESANEZ and GRIMM have lately succeeded in forming oil of rue synthetically. Starting from the fact first suggested by Hallwachs, and confirmed by Harbordt, that this oil is a mixed ketone of the formula  $\text{€}\Theta\left\{\begin{array}{l}\text{€}_9\text{H}_{19},\\ \text{€H}_3\end{array}\right.$ since it is oxidized with difficulty and yields capric acid, they distilled together equal molecules of pure dry calcium caprate—prepared from a Hungarian wine-fusel-oil—and calcium acetate. The mixture melts, swells up, blackens, and evolves at first a fluid smelling like acetone, but afterward an oil which solidifies in the neck of the retort. By fractioning this distillate, three products were obtained: one boiling below 200°; another boiling between 210° and 245°; and a solid body, caprinon, boiling above 300°. The second fraction was purified by conversion into the double salt of ammonium sulphite, crystallizing from alcohol, and decomposing by sodium carbonate; a colorless, strongly refracting oil rose to the surface, which when dried, distilled completely between 223° and 224° and had at 17·5° C. a specific gravity of 0·8295. Commercial oil of rue, treated in the same manner, afforded a liquid distilling between 224 and 225·5° and having at 18·7° C. a specific gravity of 0·8281. Analysis of the ammonium double sulphite prepared from both, and of the pure oil both artificial and natural, gave the same result. Hence oil of rue consists essentially of methyl-caprinol or nonyl-methyl ketone.—*Ber. Berl. Chem. Ges.*, iii, 518, June, 1870. G. F. B.

7. *On the action of Chlorine upon Aldehyde. A new Chloral.*—With the intention of utilizing a waste product coming from the manufacture of aldehyde and consisting of alcohol and aldehyde essentially, KRÄMER and PINNER undertook its treatment with chlorine to see if it could not be converted into chloral. A flask containing 100 grams was placed in a freezing mixture and a slow stream of dry chlorine passed into it for 24 hours. The mass became thick and nearly doubled in volume. Subjected to distillation the greater portion passed over between 160° and 180°. This was purified by agitation with sulphuric acid and redistilled. It passed over between 163° and 165°, forming a colorless oily liquid, having a strong attraction for water, so that when mixed with it, heat was evolved and the mixture solidified to a crystalline mass. The same phenomena were noticed on mixing it with alcohol. Analysis gave numbers approaching closely both crotonyl-chloral and butyl-chloral; the authors are inclined to consider it the former, since Kekulé has shown that by removing a molecule of water from two of aldehyde, crotonyl aldehyde results. In this case, the chlorine first replaces hydrogen in the aldehyde, forming chlorhydric acid, which acid acts to withdraw water and thus condense the unattacked aldehyde to crotonyl aldehyde, in which the further replacements of hydrogen by chlorine occur. This new

chloral unites readily with water, as above stated, forming a solid which when crystallized from water, forms brilliant white silky plates which obstinately retain an excess of water. This crotonyl-chloral hydrate is easily soluble in alcohol and crystallizes therefrom unchanged. Its vapors are very irritating to mucous surfaces, attacking the eyes energetically. It melts at 78°. Treatment with potassium hydrate did not decompose it as it does common chloral, into allyl-chloroform and formic acid. A heavy oily fluid of peculiar odor collected at the bottom of the vessel, having the formula $\text{Є}_3\text{H}_2\text{Cl}_2$. Upon oxidation with fuming nitric acid, it is converted readily into trichlorcrotonic acid $\text{Є}_4\text{H}_3\text{Cl}_3\text{Θ}_2$.—*Ber. Berl. Chem. Ges.*, iii, 383, May, 1870. G. F. B.

8. *On the composition of the oil of the Palm-seed.*—Palm-oil is an orange-colored fat obtained from a palm tree growing on the west coast of Africa and called by botanists *Avoira elais* (Syn. *Elais guinensis*). The natives prepare it exclusively from the fruit-pulp, the hard stone in the interior being by them thrown away. Within a few years, however, these nuts have been brought to Europe and there expressed, yielding a more or less white oil, according to the care exercised. The seeds yield from 35 to 45 per cent of oil. A preliminary examination having shown that the fat of the palm-nut differed from palm-oil, OUDEMANS subjected it to investigation. One and a half kilograms was saponified with potash, and the fatty acids were separated from the soap with dilute sulphuric acid. After cooling they were removed and washed with cold water. The larger part was distilled with water in a tinned-copper flask, the distillate (about 4 liters) carefully collected and examined. It consisted of a clear liquid smelling like a volatile fatty acid (A) with a small quantity of a solid fatty acid (B) swimming upon it. The liquid was saturated with barium hydrate, by which a small quantity of a difficultly soluble barium salt (C) separated. The liquid was filtered and evaporated to 50 cc. On cooling, about a centigram of a crystalline barium salt separated, which proved to be barium caprylate. The mother liquor afforded barium caproate. The barium salt (C) was added to the fatty acid (B) also treated with barium hydrate, the whole boiled repeatedly with water and the crystalline deposits collected and recrystallized. On analysis they proved to be barium caprate. The caprylic, caproic, and capric acids thus obtained were not more than $\frac{1}{4}$ of one per cent of the fat. The residue in the copper flask was dissolved in aqueous alcohol, cooled to crystallize the fatty acids from oleic acid, the crystalline mass dissolved in alcohol and fractionally precipitated with barium acetate. In this way, the fat of the palm-nut was shown to be composed of glycerides of lauric, palmitic, stearic and oleic acids, with traces of tricaprin, tricaprylin, and tricaproin (perhaps also trimyristin). Quantitatively, Oudemans finds the triolein to be about 27 per cent, tristearin 31·7 and tri-laurin 41·3 per cent, of the fat of the palm-nut.—*J. pr. Ch.*, II, ii, 393, Dec. 1870. G. F. B.

II. GEOLOGY AND NATURAL HISTORY.

1. *On the Mineralogy of Eozoon Canadense.*—Dr. ROBERT HOFFMANN of Prague has submitted to chemical and mineralogical investigation the Eozoon Canadense, found at Raspenau in Bohemia, (*Jour. für prakt. Chemie*, May, 1869). He describes the Eozoon mass as having a superficial resemblance to that of Canada, appearing in waved or concentric bands, oval in form, or else in irregular acervuline aggregates. In the oval banded portion the shell of the Eozoon, a nearly pure, finely granular calcite, can be separated from the mineral representing the sarcode, which is described by Hoffmann as a cast of the soft parts of the Eozoon, formed through infiltration of watery solution either during the growth or immediately after the death of the animal. It is a peculiar silicate, fine-grained, grayish-white and somewhat translucent, the analysis of which is given below, (I). Associated with this is a finely granular dolomite, destitute of any traces of organic structure, which sometimes appears to have served as a center or point of attachment to the growing Eozoon. In other cases, however, broken fragments of older Eozoon had served as nuclei, and become surrounded with a fresh growth. These materials, which constitute what Hoffmann has described as the Eozoon reef, are associated with two other silicated minerals. One of these, allied to fahlunite, has a specific gravity of 2·687, is grayish-brown or greenish-black in color, dull, or with a somewhat fatty luster, and nearly opaque. This substance, whose analysis is given under II, forms nearly parallel streaks in the central parts of the Eozoon reef, and moreover surrounds it, intersecting and wrapping around the Eozoon mass in multiplied layers, a line or more in thickness, which are interlaminated with a light green mineral, transparent, with a somewhat vitreous luster, and a density of 2·56. It is a hydrous silicate (III), allied to picrosmine and is more or less penetrated by magnesite.

	I.	II.	III.
Silica,	53·388	36·425	52·677
Alumina,	10·521	32·944	1·260
Ferrous oxide,	10·091	20·140	1·011
Magnesia,	11·127	-----	30·414
Lime,	1·048	·678	-----
Potash,	1·378	2·721*	1·900
Soda,	2·094	-----	·233
Water,	10·991	7·092	11·865
	100·638	100·000	99·360

The band of Eozoon rocks at Raspenau lies between silicated schistose rocks beneath, and overlying beds of granular limestone, some of them grayish white, and others blackish from an admixture of carbonaceous matter. One of these gave to analysis 1·100 of carbon, 2·332 of insoluble matter, and 4·708 of carbonate of magnesia, the remainder being carbonate of lime. The composition of the Eozoon shell is given under IV, that of the dolomite under V, and that of the magnesite which penetrates the silicate, III, under VI.

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* Akalies determined by loss; some soda was present.

	IV.	V.	VI.
Carbonate of lime,	97·711	53·815	5·581
Carbonate of magnesia,	traces	40·420	84·651
Carbonate of iron,	1·660	-----	1·001
Alumina,	·629	-----	8·767
Insoluble,	(phosph. traces)	1·260	-----
	100·000	95·495	100·000

T. S. H.

2. *On a Mineral Silicate injecting Paleozoic Crinoids;* by T. Sterry Hunt, F.R.S.—A Silurian limestone from near Woodstock, New Brunswick, lately examined microscopically by Dr. Dawson, was found by him to consist almost wholly of comminuted organic remains, including fragments of trilobites, gasteropods, brachiopods, and joints of small encrinal stems and plates; the whole cemented by calcareous spar in a manner similar to many organic limestones. He observed, however, that the pores of the crinoidal remains were injected by a peculiar mineral, readily distinguishable in thin transparent sections, or on surfaces which had been exposed to the action of an acid, which dissolves the carbonate of lime and places in relief the injecting mineral. The minute structure thus revealed is precisely similar to that of recent crinoids studied by Carpenter, and will soon be described and figured by Dawson. Decalcified specimens exhibit a congeries of curved, branching and anastomosing cylindrical rods of the replacing mineral, sometimes forming a complex network, which, under the microscope, resemble the coralloidal forms of aragonite known as *flos ferri*, and present a frosted crystalline surface. The same mineral, as observed by Dr. Dawson, occasionally occupies larger interstices among the fragments, and was evidently deposited before the calcareous spar which cements the whole mass.

When this limestone is dissolved in dilute hydrochloric acid, the residue, washed by decantation, equals from five to six per cent of the weight of the mass, and is seen under a microscope to consist entirely of the casts composed of the mineral just noticed, mixed with about one-fourth of coarse siliceous sand. This matter is pale grayish-green in color, but when calcined becomes of a bright reddish-brown, without change of form. Heated in a close tube it gives off water, and becomes much darker in color. It is partially attacked by strong hydrochloric acid, which takes up much protoxide of iron; but is readily and completely decomposed by hot concentrated sulphuric acid, leaving a skeleton of silica which, by a dilute solution of soda, is readily separated from the intermingled grains, more or less rounded, of colorless vitreous quartz. The analysis of 1·187 grams, effected by decomposing it in the way just mentioned, yielded silica ·3290, alumina ·2440, protoxide of iron ·1593, magnesia ·0360, potash ·0140, soda ·0042, water ·0584, insoluble quartz ·3420=1·1869. This calculated for 100·00 parts of the silicate gives as follows; silica 38·93, alumina 28·88, protoxide of iron 18·86, magnesia 4·25, potash 1·69, soda 0·48, water 6·91. The analysis of another portion of ·526 grams by fusion with an alkaline carbonate gave, by calculation for the silicate, 18·80 of protoxide of iron, and amounts of alumina and combined silica closely agreeing with those found above. The oxygen ratio for $\ddot{\mathrm{Si}}$, $\bar{\mathrm{R}}$, $\dot{\mathrm{R}}$, $\dot{\mathrm{H}}$, is as 20·77 : 13·46 : 6·29 : 6·14, or nearly as 3 : 2 : 1 : 1. This mineral approaches closely in composition to jollyte, but differs from it in containing a portion of alkalies, and but one half as much water. In these respects it agrees closely with a silicate found by Robert Hoffmann with the Laurentian Eozoon of Raspenau, (Jour. für prakt. Chem., May, 1869, and this volume, page 378). This latter is compared by Hoffmann to fahlunite, to which species also jollyte is allied in physical characters as well as in composition (Dana's Mineralogy, page 493.) Under the names of fahlunite, pinite, etc., is included a great class of hydrated silicates, which, from their imperfectly crystalline condition, have generally been regarded, like serpentine, as the results of the alteration of other silicates. It is, however, difficult to admit that silicates found in the condition described by Hoffmann, and still more the present mineral, which injects the pores of paleozoic crinoids, can be any other than original depositions, allied in the mode of their formation to the serpentine, pyroxene and other minerals which fill the chambers and canals of the Laurentian Eozoon, and to the glauconite which occurs in a similar manner in Tertiary and recent shells. The limestone from Woodstock, apart from the insoluble matters just described, is very pure, yielding only 1·80 p. c. of alumina and iron-oxide, and magnesia equal to 1·35 p. c. of carbonate.

Montreal, March 10, 1871.

3. *On native amorphous Mercuric Sulphide.*—G. E. MOORE has recently examined a specimen of black mercury-ore collected in Lake county, California, by Professor Whitney. It occurs as a coating on the sides of cracks and crevices in a peculiar quartzose gangue, and is accompanied by crystallized and massive iron and copper pyrites, and very minute cochineal-red crystals of cinnabar. Its physical properties are thus given:—Entirely without structure or cleavage. Fracture semi-conchoidal to uneven, fracture-surfaces brilliant. Very brittle when struck or bent, yet tough when cut. Rubbed in an agate mortar the powder becomes a solid mass, taking a high polish and a metallic luster like graphite. Color grayish-black. Luster metallic. Streak on porcelain pure black. Cut surfaces brilliant. Hardness about 3 on Mohs's scale, somewhat greater than cinnabar, though difficult to estimate exactly on account of its brittleness. Specific gravity 7·701 to 7·748; somewhat different in different specimens on account of admixed cinnabar. Before the blowpipe it behaves like cinnabar. In the closed tube, it sublimes completely, with the exception of a trifling residue of quartz and iron oxide. The black sublimate yields a

cinnabar-red powder when care is taken that the upper part of the tube is heated to near the subliming point of the cinnabar. A qualitative analysis showed mercury and sulphur, with small quantities of iron and silica. Quantitatively examined it yielded as follows:—Sulphur 13·82, mercury 85·79, iron 0·39, quartz 0·25. Whence its composition is

$$HgS, 98{\cdot}92;\ FeS_2, 0{\cdot}83;\ \text{Quartz}, 0{\cdot}25 = 100{\cdot}00.$$

Experiments to determine the chemical cause of the difference in properties between this mineral and cinnabar, resulted negatively. Moore concludes that the mineral in question is completely identical with the black amorphous mercuric sulphide of the laboratory, and proposes for it the name Metacinnabarite.—*J. pr. Ch.*, II, ii, 319, Nov. 1870. G. F. B.

4. *Freieslebenite and Diaphorite.*—Von Zepharovich has shown (Sitz. Acad. Wiss. Wien, 1871), that Freieslebenite includes two species of similar composition ($Ag_4Pb_3Sb_4S_{11}$) but different crystallization. He retains the original name for the *monoclinic* species and gives the name diaphorite to the *orthorhombic.* The former is from Freiberg and Hiendelaencina in Spain, and has for the ratio of the inclined diagonal, the orthodiagonal and the vertical axis 1 : 0·5871 : 0·9277; and the inclination of the last is 87° 46′; sp. gr.=6·35. The diaphorite is from Przibram and Freiberg, and has for the ratio of the diagonals and vertical axis 1 : 0·4919 : 0·7344; and sp. gr.=5·90.

5. *On the Eocene beds of Utah;* by T. A. CONRAD. (From the author.)—I am indebted to Prof. Cope for an opportunity to examine some Eocene fossil shells, collected at Aspen station, and at Quaking Asp Ridge, east of Bear river, Utah, at an elevation of 7,100 feet. These fossils were taken from the rock in which they were imbedded, by Lucius C. Ricksecker, engineer on the Pacific Railroad. They are imbedded in indurated clay, and suggest the probability that they lived in a river rather than a lake, especially as there is a genus of Cyrenidæ (*Veloritina* Meek) as well as one of Corbulidæ (*Anisorhynchus* Conrad) which lived apparently in company with Unionidæ and Melaniidæ. These fossils are especially interesting in consequence of the light they cast on the condition of the globe in the earliest Eocene period. This group immediately overlies the Cretaceous strata, and corresponds with the Lignite beds at the base of the Paris Eocene and those of Provence described by Matheron, which is the first supracretaceous group of strata known to occur in Europe, and according to Matheron has a "colossal development;" and of his first stage of Lignite, he remarks that where the lower bed is in contact with the chalk, it shows fragments of marine shells not easily determined, but he recognizes *Ostrea* and *Cardium.* This is probably the broken up surface of the Cretaceous formation which emerged above the sea, a condition naturally following the agitation of the waters of a retiring ocean. Upon this bed follows five stages of Tertiary Lignite of fresh water origin, the lower beds containing *Unio Toulouzanii* (*Loxopleurus* Meek), *Cyrena globosa*, and *C. Fesrussaci.* This mixture of fresh and brackish water genera corresponds with

the lowest beds of the Eocene in North America. This exact correspondence in stratigraphical position between the European and American older Eocene, as well as in the hydrography and topography of the respective continents at that period, is elucidated by the affinity of the fossils as regards their peculiar generic characters. Thus the genus *Loxopleurus* Meek originated and died out with the older Eocene fauna. This was also the case with *Veloritina* Meek, a genus closely allied to if not identical with a genus which Deshayes regards as *Cyrena*, but arranges in a separate section (*C. Trigones*). He describes ten species of the Paris basin and Matheron one from Provence (*C. globosa*). This genus is unknown in later Eocene strata. A gasteropod of the family Melaniidæ cannot be distinguished generically from one in the Lignite beds of Provence, named *Melanopsis armata* by Matheron. This is the *Tiara* (*Pyrgulifera*) *humerosa* Meek. It is a well characterized genus, very distinct from *Tiara* and more nearly related to *Melanopsis* Ferrus. It is also limited to the lower Eocene, and was probably an estuary or brackish water shell, although its nearest living form is *Varena crenocarina*, which inhabits the Pedro Branca river, Bahia. *Loxopleurus* Meek is related on one side to *Castalia* and on the other to *Trigonia*, which latter genus apparently became extinct in the Cretaceous era, for it is unknown in Tertiary formations, and reappears in the actual seas with very different external characters and I think without genetic descent from the fossil species.

The marine equivalent of this lower Eocene formation is probably to be found in the division B, of Mr. Gabb's Cretaceous fossils of California.

The hydrography of this early Tertiary era may be imagined from the foregoing statement to have been a river system analogous to that of Brazil at the present time. The presence of vast numbers of estuary shells forbids us to suppose that the group inhabited lakes rather than rivers, which rose in not greatly elevated hills, for mountains, except as isolated peaks, had hardly been developed at this period, when the great basin of Utah was submerged, and the Mississippi valley and its rivers were not yet formed, but the general drainage was into the Pacific ocean. There was then a system of great rivers and a densely wooded country eminently fitted for land animals, whose remains I have no doubt are to be found, if they have not been already obtained. The elevation of this vast region to any considerable height took place in the first stage of the Eocene era, and if we are surprised at the great extent of such brackish water rivers, we have only to glance at a similar river system 2,200 miles up the Amazon. By the rise of the Cretaceous formation, this condition of the country was formed, and as no transition beds are known, the advent of new genera and species so different from what had lived before is an unexplained phenomenon in the geological history of the globe.

So far in Europe, I believe, no authentic account has been published of any fossiliferous beds between the lower Eocene and the Cretaceous strata, that would indicate a transition period to have intervened. And so in Utah, Idado and Wyoming, the same remarkable condition is apparent, as it is in the Eastern States, in England, France, Spain, India, on the banks of the Nile and in South America, which proves that the revolution which closed the Cretaceous era was co-extensive with the globe and destroyed the life of the period.

6. *Coal Plants of the Illinois Geological Survey, 4th Volume.*—Mr. Lesquereux's chapter on coal plants, in the fourth volume of the reports of the Geological Survey of Illinois, embraces descriptions of 78 new species. It also includes remarks upon numerous instructive specimens of previously described species (40 of which had not before been recognized in America), and is, as a whole, the most valuable contribution to the history of our American coal plants which has appeared since the publication of the Pennsylvania Report in 1858.

At the close of the descriptive part of the report (p. 471), the author gives the list of the species of plants thus far identified from the Illinois coal field, showing their geographical distribution. This, however, is not to be considered an estimate of their *actual* distribution, as the author states, because of the very extensive explorations at one or two points, and the almost entire neglect of large portions of the field which would probably, if explored, yield fully as rich collections.

The report closes with a pretty full discussion of the "Mode of Preservation of Vegetable Remains in our American Coal-measures," of the "Affinities of the Illinois Coal-flora," and of the "Stratigraphical and Geographical Distribution of the Coal-flora."

We have here mention of the fact that plants are sometimes found in good preservation in the solid coal, as well as in the disintegrated form of mineral charcoal which often occurs between the layers of the denser coal. "This [former] case is especially observable in a kind of hard laminated flint coal, obtained in Mercer county by Mr. H. A. Green [of the Survey], which bears on the horizontal surface of its crystalline lamellæ, however thin they may be cut, the outline and nervation of leaves and branches of ferns and other vegetables of the coal; and these are so distinctly marked that the most delicate parts are as easily identified as those of plants preserved in shales. The great abundance of these remains shows that the whole mass of this coal, which is true coal and burns freely, is a compound of them.

In shales, the leaves of ferns and other plants are sometimes finely preserved in the form of extremely thin layers of coal; while, in other cases, the carbonaceous matter has nearly disappeared, leaving barely enough to show the outlines of the fossil. In still other cases, we find larger or smaller fragments of the cuticle of plants, not completely altered to coal, of a reddish-brown color, and retaining considerable elasticity. "The shales, according to the amount of vegetable matter mixed in them, and the depth at which they have been formed under water [?], are of a more or less dark color; whitish or yellowish, when of fresh water origin, and with few remains of plants; black and generally more homogeneous when formed in deep water, and having, for a larger proportion of their compound, broken remains of organized beings."

The author is not satisfied to refer to ordinary concretion or segregation, the formation of the ironstone nodules from Mazon Creek, which have yielded so many ferns, insects, crustaceans, etc. He says:—" from their position, their form and size, varying according to the nature and outline of the bodies which they contain, the nodules of Mazon Creek rather seem to be the work of infusoria or *Bacillaria* concentrating molecules of iron around some centers, as now happens in the formation of bog iron ore, or in other deposits in springs or pools whose waters contain a solution of iron. This supposition appears confirmed by the manner in which the bodies in concretions have been preserved and selected for preservation. Though generally merely fragments, their integrity is complete; and yet some of them are of very soft texture. The pinnæ or leaflets of ferns are always found in them in a flattened position, their axis or rachis extending through the center of the elongated nodule, with the divisions on both sides; the surface of the pinnules slightly swollen, as when in their living state, is marked by recognizable hairs or fruit dots, with distinct veins and vainlets; and their appendages, like the scales, are seen in the various modifications which they present in the living specimens. * * The small organs of plants appear, then, in a better state of preservation than in the shales. With small animals like crustaceans, scorpions, insects of a fleshy and very delicate texture, the preservation of form is still more remarkable. They are found entombed in the middle of the nodules just as if they were in life, or as if they had been transformed into stone while still living. The fruits or nutlets are not flattened. * * Peculiar species of plants and animals seem to have been selected as the nuclei of these nodules," certain forms which are abundant in them being scarce or entirely wanting, so far as observed, among the fossils of the shaly portion of the same bed at Morris five miles off, and *vice versa.* F. H. B.

[We propose to continue this notice in another number.]

7. *The Bone Cave of Eastern Pennsylvania* (p. 335).—Recent letters from Mr. Wheatley state that the cave is constantly making new disclosures. He writes:

Of Megalonyx, I have 30 to 40 teeth and 3 in the *jaw;* and parts of 17 individuals of the sloth tribe. Prof. Cope has this day read a paper before the American Philosophical Society describing the following species of vertebrates: *Megalonyx splenodon* Cope, *M. tortulus* C., *M. toxodon* C., *M. Wheatleyi* C., *M. dissimilis* Leidy; *Mylodon Harlani* Owen; *Arvicola hiatidens* C., *A. sigmodus* C., *A. pinetorum* LeConte, *A. involuta* C., *A. speothen* C.; *Hesperomys ?leucopus* Raf.; *Jaculus ?Hudsonius* Temm.; *Erethizon cloacinus* C.; *Sciurus calycinus* C., *S.* ——*?; Lepus sylvaticus* Bachm.; *Scalops?* ——*?; Vespertilio?* ——*?; Tapirus Americanus* Brisson, *T. Haysii* Leidy; *Mastodon Americanus* Cuv.; *Bos* ——*?; Equus* ——*?, E.* ——*?; Ursus pristinus* Leidy; *Felis* ——*?; F.* ——*?; Canis* ——*?; Crotalus* ——*?, Coluber* ——, *C.* ——*?; Tropidonotus* ——*?; Cistudo* ——*?; Emys* ——*?; Rana* ——*?,* *Meleagris* —— ?, *Scolopax* —— ?; not identified 3. The whole number is 41 species; 6 of them Edentates, 12 Rodents, 1 Insectivore, 1 Chiropter, 8 Ungulates, 4 Carnivores?, 2 Birds, 6 Reptiles, and 1 Batrachian. Dr. G. H. Horn has examined the insects and has recognized among them the following species: *Cychrus Wheatleyi*, *C. minor; Cymindis aurora; Chlænius punctatissimus; Pterostichus lævigatus*, *Pt. longipennis; Dicælus alutaceus; Aphodius scutellaris*, *A. micans; Phanæus antiquus; Copris punctulatus; Saprinus? ebeninus.* He also observes that there are several others which he does not venture to name.

8. *On Fossil Vertebrates of Caves on the Island of Anguilla, W. I.;* by Dr. Cope, (Proc. Amer. Phil. Soc., Nov. 18, 1870).—These vertebrates include a crocodilian, two birds, one deer and five rodents. Three of the rodents were of gigantic size, and included, besides two species of Chinchilla already described (loc. cit., 1869, 193) a third, still larger, the *Loxomylus latidens* Cope. The bones of the deer indicated a species little over half the size of the Chinchilla.

9. *Report on the Progress of the State Geological Survey of Michigan;* presented Nov. 22, 1870, by Alexander Winchell, Director. 64 pp. 8vo. Lansing, 1871. Published by authority of the State.—The survey of Michigan now in progress was ordered by the State in 1869, when $8,000 per annum were appropriated for the purpose. The appropriation was to be divided equally between the surveys of the Upper and Lower Peninsula, and in this way the work has now been carried forward for two years. Toward the survey of the Marquette district, Major T. B. Brooks has been engaged, and for the copper region, Professor R. Pumpelly.

The pamphlet issued is only a brief statement of the objects of the survey and of some of its results. Among the facts mentioned under the head of General Geology are the following.

The water-lime group of the Lower Helderberg rocks occurs in the State near the west end of Lake Erie in Monroe Co., and also on Mackinac Island, and the mainland of the Upper Peninsula to the west. The Huron group of rocks, as Prof. Winchell has before announced, is referred by him to the Portage and Chemung, and the Marshall group to the Subcarboniferous.

Among the western and northwestern borders of the Lower Peninsula, the *boulder drift* is underlaid by "vast horizontal beds of bluish and pinkish clays, nearly free from boulders, and diversified with occasional seams of lignitic and soil-like material," which rest on the scratched rocks. The boulder deposits are distributed through beds of obliquely laminated sands and clays, and on these rest the lakes and peat bogs of the State. In these upper deposits are found remains of the elephant, mastodon, and Castoroides.

Prof. Winchell also mentions the discovery of *an ancient outlet of Lake Superior* through the valley of Au Train and Whitefish rivers into Little Bay de Nocquet and Green Bay of Lake Michigan; it is a deep valley bordered with high bluffs, mostly limestone at bottom, across between Lake Superior and Little Bay de

Nocquet. He adds, "It may easily be that the elevation (of the ancient valley), is just such as to justify the project of a ship canal across the divide, with the view of shortening the voyage" between the ports of the two lakes. This outlet lies in the prolongation of the axis of Green Bay, "and recalls opinions formerly entertained, based solely on topographical data, that Green Bay was once prolonged through Lakes Winnebago and Horicon in Wisconsin." This elongate hydrographical basin conforms in its longer axis with the direction of the glacial striæ and boulder transportation.

10. *Note on Limestone containing Petroleum in Nova Scotia;* by D. HONEYMAN, (Edit. Corr., dated Halifax, Nova Scotia, Provincial Museum, March 28, 1871).—We have recently received a quantity of Lower Carboniferous limestone from Kempt in this province, having numerous cells with small crystals of calcareous spar and petroleum. When the limestone is broken, you almost invariably find the cells with the petroleum, the latter having a honey-like appearance. The limestone is in connection with gypsum.

11. *New York State Cabinet of Natural History:* 20th Report. 1867. 448 pp. roy. 8vo, with numerous plates and wood-cuts.—This beautiful volume is a reprint of the State Cabinet Report for 1867, or rather it is from a revised edition of it. It is the most extended and valuable of the series, and well deserved reproduction in a better form. A notice of it appeared in this Journal in vol. xlvi, 1868. It contains Hall's admirable paper on the Graptolites, illustrated with many wood-cuts and four plates; descriptions of a very large number of fossils of the Niagara group, with figures of the species on 21 excellent plates; also several shorter papers. Some of the latter are controversial, and have already been the subject of remark in this Journal.

12. *Saurocephalus of Harlan.*—Dr. COPE observes (Proc. Phil. Soc., Nov. 18), that the genus *Saurocephalus*, instituted on Cretaceous fishes, instead of being Acanthopterygian, is Malacopterygian, and between the Salmonidæ and Amiidæ. The spines and rays have been regarded by some authors as of the Cestraciont genus *Ptychodus*.

13. *Geology of Ohio.*—We understand from Prof. Newberry, the director of the Geological Survey of Ohio, that another Annual Report is ready for the press. If the plans of Dr. Newberry are sustained and carried out by the State, Ohio will not be behind Illinois in the character of its final Report.

14. *Note on Asaphus platycephalus, by* J. D. DANA.—The closing remark in my paper on page 321 will have to be canceled, if the species, there referred to *Asaphus platycephalus*, is identical with the *Asaphus platycephalus* (*A.* (*Isotelus*) *gigas*), of Trenton, the latter (as Mr. Billings writes the author) often occurring in New York rolled into a ball.

15. *On the Earthquake at Oahu, Hawaian Islands, on Feb.* 19; by Professor W. D. ALEXANDER. (From a letter to J. D. Dana, dated Oahu College, Feb. 28, 1871).—We have a letter upon this earthquake, by Professor Alexander, of Honolulu, which will appear in our next.

16. *Claparède on Marine Bryozoa.*—In the first number of vol. xxi of Siebold u. Kölliker's Zeitschrift, Claparède, who with the exception of Nitzsche is the only writer who has studied the Bryozoa since the publication of the capital papers of Smitt, gives us most interesting contributions to their history. While on the main points he completely agrees with the views taken by Smitt of the polymorphism of the species, their mode of budding and general embryonic development, yet in some points not satisfactorily determined by Smitt, such as the relations of the various cells (zoœcia) to one another, the nature of Smitt's "mörka kroppar," dark bodies, and "fett kroppar," he has new observations differing somewhat from those of Smitt. The most interesting facts are those concerning a sort of retrograde development, a resorption of the digestive cavity in the older cells, the gradual disappearance of the lophophore, resulting in cells usually considered as dead, but in reality having latent life, and where alone the fatty bodies of Smitt, which play such an important part in the embryology of Bryozoa, are developed. These cells apparently pass through stages identical with those produced by budding at the youngest extremity of the colony, with the difference that in one case the cell is immature, while in the other it is fully developed. The resorption is frequently accompanied by peculiar changes in these cells, and is confined to the older portions of the Bryozoan colony in which the lateral connection between the cells for exchange of fluids between the cells provided with digestive cavities and those cells containing latent life, is very strikingly shown, thus forming a complete circulation between the most distant parts of the colony. He also confirms the nature of the colonial nervous system, first traced by Fritz Müller, and shows its existence among the Chilostomata, where it had only been traced by Smitt before. Claparède closes this interesting paper by giving us the complete development of Bugula, with larger, more accurate, and at the same time more intelligible figures than we have had of the early development of any one species of marine Bryozoa thus far. He has, however, not been able to decide positively the nature of the ova, said in one case to owe their origin to a sexual process, and in the other cases to point to the existence of parthenogenesis among Bryozoa, under certain circumstances. Claparède has not confirmed the observations of Schneider on the development of Membranipora, but from what Nitzsche has observed of the early stages of Bugula, he appears to have seen the same retrograde development in the youngest stages of its larva which Schneider observed in Cyphonantes during its development into Membranipora. A. AG.

17. *Ceratodus, its place in the system of Fishes.*—The *Ceratodus Forsteri* of Krefft (Proc. Zool Soc., 1870, 221), a fish from Australia supposed to be congeneric with the *Ceratodus* of Agassiz from the Devonian, first made known by Hon. WM. FOSTER three years since, has been recently studied by Dr. Günther, and an extended memoir on it has been presented by him to the Royal Society. We take the following facts from an abstract of this memoir

in the Ann. Mag. Nat. Hist., IV, vii, 222. The skeleton is of the type so well known from the descriptions of *Lepidosiren* and *Protopterus* by Owen, Bischoff and Hyrtl. The teeth are much like those of *Protopterus*, *Psammodus*, *Dipterus*, etc., in microscopic structure, and identical with those of the fossil *Ceratodus*—confirming thereby Mr. Krefft's reference of the fish to the last mentioned genus. Dr. Günther names a second Australian species *Ceratodus miolepis*.

Messrs. A. Hancock and T. Atthey have an article on the subject in the same volume of the Ann. Mag. Nat. Hist., p. 190, in which they present the conclusion that, while the fish referred to is nearest to *Lepidosiren*, it is probably more distinct in genus from the Devonian *Ceratodus*, than from *Ctenodus* and *Dipterus*, especially the former (these two genera for reasons stated being kept separate). *Ceratodus*, they observe, "is probably a true Cartilaginous fish, and consequently a Selachian or Placoid," and the fact that only its dental plates are known, nothing of the bony supports of the same having been found, is urged as sustaining this view.

18. *Coccoliths.*—*Coccoliths*, calcareous disk-shaped organisms, regarded by Huxley at first as a unicellular plant (alga), and afterward the secretions of his Bathybius (analogous to the siliceous spicula of a sponge) have been recently examined by H. J. Carter (Ann. Mag. Nat. Hist., IV, vii, 184), and found to be what they were first pronounced. Carter finds them very abundant in shallow waters as well as profound depths. After mentioning the results of chemical examinations in which he found a "granular protoplasmic disk remaining after the action of acetic acid, he adds:

> "Thus, still more convinced that I had a unicellular Alga under examination, and taking a portion of the little arborescent fronds of *Melobesia calcarea* ("the chalk-*Melobesia*"), which, in about ten fathoms, occurs here in accumulated beds or banks of probably miles, certainly acres, in extent, I pulverized a portion for examination, and observed several fragments whose cells, but for their polygonal arrangement, presented very much the appearance of the coccolith in their concentric lines, transparent area. and central granule, together with the absence of blue color under the iodine test.
>
> Lastly, considering that the coccolith is so abundant in the Laminarian zone here, and so voraciously fed upon by the Echinodermata and Ascidiæ, also that it is so nearly allied in composition, structure, and habit to *Melobesia calcarea*, that it chiefly forms the bed of the Atlantic ocean, and that it is found fossilized in the chalk, I cannot help inferring that it is a vegetable organism which contributes chiefly to form the calcareous deposits of the present day in many parts, and has done so in the formation of calcareous ones of the past, at all events that of the chalk."

He names two species *Melobesia unicellularis*, from the Atlantic ocean bottom, and also the Laminarian zone on the South coast of Devon, and *M. discus*, from the Atlantic ocean, each stated as "accumulating in beds." The cell in each is described as calcareous, discoidal or discal, transparent, convexo-concave, consisting of two convexo-concave disks, one a little larger than the other and receiving the smaller one in its concavity, and enclosing a granular protoplasmic disk, with a central transparent area. The first is obtusely elliptical, and about $\frac{1}{1700}$th in. long and

$\frac{1}{12000}$th in. thick; the second is circular and about $\frac{1}{2350}$th in. in diameter. The latter is not found in the Laminarian zone.

Coccospheres of Huxley are of two kinds, and are made up of frustules of the above species, the two different kinds never occurring mixed in one coccosphere. Carter regards the coccospheres as the "*sporangia* of the two species of *Melobesia.*" Besides the two distinct kinds of coccospheres, there are also the "loose type" of coccospheres of Huxley. This, Mr. Carter has not seen, but he conceives that they may represent more developed form of the sporangium or coccosphere, perhaps undergoing dehiscence.

The coccoliths must furnish food for the lower animals over the bottom of the deep sea, as they do for those along its borders.

19. *Transactions of the Connecticut Academy of Arts and Sciences*, Vol. I, Part 2. 376 pp. 8vo, with 7 lithographic plates. New Haven, Feb., 1867 to March, 1871.—This work has been much delayed by a fire, by which most of it was destroyed in 1869. It is entirely occupied by the "Notes on the Radiata in the Museum of Yale College," by A. E. Verrill. Under this head there are nine distinct articles: No. 1, Descriptions of New Starfishes from New Zealand; No. 2, Notes on the Echinoderms of Panama and west coast of America, with Descriptions of new Genera and Species; No. 3, On the Geographical Distribution of Echinoderms of the west coast of America, with a Comparison of the Tropical Echinoderm-Faunæ of the east and west coasts of America; No. 4, Notice of the Corals and Echinoderms collected by Prof. C. F. Hartt at the Abrolhos Reefs, Province of Bahia, Brazil, 1867; No. 5, Notice of a collection of Echinoderms from La Paz, Lower Cal., with Description of a new Genus; No. 6, Review of the Corals and Polyps of the west coast of America (six plates); No. 7, On the Geographical Distribution of the Polyps of the west coast of America; No. 8, Additional Observations on Echinoderms, chiefly from the Pacific coast of America; No. 9, On the Echinoderm-Fauna of the Gulf of California and Cape St. Lucas. All these articles, except the three last, have been noticed in this Journal, from time to time, when they have been published as separate pamphlets.

Nos. 6 and 7 have also been issued under one cover, forming a pamphlet of 193 pages, with six plates. The early parts of No. 6 were noticed in this Journal last year. In the portion describing the Madreporaria several changes have been introduced in the classification, of which the most important is the institution of a new sub-order (*Oculinacea*) to include *Stylasteridæ* Gray (emend.), *Oculinidæ*, *Pocilliporidæ* Gray, *Stylophoridæ*, *? Stylinidæ*, *Astrangidæ*, *Caryophyllidæ*. Several changes are made in the limits and characters of the families and genera: *Madreporidæ* is made (as by Prof. J. D. Dana) to include both *Madrepora* and *Montipora;* *Astrangidæ* is extended so as to include *Cladocora* and its allies; the *Caryophyllidæ* of Edw. and Haime are divided into two families, the second division, *Turbinolidæ*, corresponding nearly with *Turbinolinæ* E. and H.; *Agaricidæ* Gray (emend.) is adopted instead of *Lophoseridæ*. The relations of *Pocillipora* are discussed anew, and the author's view, previously expressed in other works,* that *Pocillipora* is a true Polyp, and not at all allied to *Millepora* and other Hydroid corals, is again insisted upon, and the relations of the *Pocilliporidæ* to certain fossil corals is discussed. "Its affinities with numerous extinct genera having the same tabulate structure, is a matter requiring a great amount of careful investigation. From *Favositidæ*, as a whole, it differs in having an abundant cœnenchyma. *Favosites* differs also in having perforate walls, and doubtless ought to be separated, at least as a distinct family, which has, perhaps, closer relations with *Madreporacea*."† A number of new corals are also described and, in the Addenda, some additional new *Gorgonidæ*.

In No. 7, lists are given of the species found in each of the faunal divisions of the west coast, with their range, etc., and in some cases special local lists are added. In the Panamian Fauna 104 species occur, none of which have been found beyond the limits of that zoölogical province. The plates are chiefly devoted to the Gorgonacea, and two of them illustrate the spicula of many species.

20. *Second and Third Annual Reports of the Trustees of the Peabody Academy of Science for* 1869 *and* 1870, Salem, Mass., received March, 1871.—This report contains the services on the occasion of dedication of the Museum, with the address of the President of the Academy and remarks by others; the Proceedings of the Trustees; the annual reports of the officers of the Academy; lists of Additions to the Museum; and an Appendix containing several zoölogical articles. Prof. A. Hyatt gives an account of a specimen of *Rossia palpebrosa* Owen (?) taken from the stomach of a hake at Manchester, Mass.,—a species not before recorded from our coast. Prof. E. D. Cope contributes a Catalogue of Batrachia and Reptilia obtained by J. A. McNiel in Nicaragua, and another of those obtained by C. J. Maynard in Florida; in the former article he describes a new lizard and a new genus and species of serpents (*Enulius murinus*); in the latter a new lizard and a new salamander (*Manculus remifer*). Prof. A. S. Packard gives a list of the Insects collected at Pebas, Ecuador, by Prof. J. Orton, and describes a new species of *Attacus* (*A. Amazonia*). Mr. S. I. Smith contributes a list of the Crustacea collected by J. A. McNiel in Central America, and describes a number of new species belonging to the genera, *Leptopodia*, *Ozius*, *Arenæus*, *Gebia*, *Atya* (2 sp.), *Evatya* (new genus), *Leander*, and *Palæmon*. Several species in the collection appear to be identical with Atlantic species. The omission of the precise dates of publication of these descriptive papers is inexcusable. The report is merely dated "1871."

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* On the Affinities of the Tabulate Corals, in Proc. Amer. Assoc. for Adv. of Science, 1867, p. 148; also Proc. Essex. Institute, vi, p. 90, 1869.

† Since the printing of these remarks (April, 1870), a very interesting new genus of recent tabulated corals has been described by Mr. W. S. Kent, under the name of *Favositipora Deshayesii* (Ann. and Mag. Nat. Hist., vol. vi, p. 384, pl. 17, 18, Nov., 1870). This remarkable form combines a complete tabulate structure of the interior, like *Favosites*, with the ordinary structure of *Alveopora* in other respects, thus fully confirming the views quoted above.

21. *On the Genesis of Species;* by St. George Mivart, F.R.S. 296 pp., 12mo, with numerous illustrations. London, 1871. (Macmillan & Co.)—This work presents the fairest and most successful argument against the sufficiency of the theory of "Natural Selection" which has thus far been published. At the same time, the author, in his two closing chapters, sustains the view of an evolution of species by secondary laws; but laws "for the most part unknown," and among which that of "Natural Selection" is only of subordinate importance. The illustrations are excellent.

III. Miscellaneous Scientific Intelligence.

1. *Anthracite Coal Trade of Pennsylvania.*—Mr. Peter W. Sheafer, a well known engineer at Pottsville, Pa., has prepared a diagram exhibiting the progressive development of the Anthracite Coal Trade of Pennsylvania. It embraces the period of fifty years from 1820 to 1870, and an accompanying table gives in detail for each year, the yield of anthracite of the four great subdivisions of the anthracite region, the Lehigh, the Schuylkill, the Wyoming, and the Lykens Valley, Shamokin, etc. We take the export in tons, for the years below specified, from the table:

	Lehigh.	Schuylkill.	Wyoming.	Lykens V., etc.	Total.
1820	335				365
1830	41,750	89,934	43,000		174,734
1840	275,313	475,091	148,470	15,505	864,384
1850	690,456	1,782,936	827,823	57,684	3,358,899
1860	1,821,674	3,270,516	2,941,817	479,116	8,513,123
1870	3,172,916	3,853,016	7,825,128	998,839	15,849,899

The Schuylkill trade began in 1822, with the exportation of 1,480 tons; the Wyoming, now twice the largest, in 1829, with 7,000 tons; the Lykens Valley, etc., in 1839, with 11,930 tons.

2. *Carbonic acid in outside and indoor air.*—According to examinations made at the Massachusetts Institute of Technology, by A. H. Pearson, under the direction of Prof. Storer, the amount of carbonic acid in the air at the Cupola of the State House, Boston (May 18, 1870), was ·03139 per cent of volume; in Newbury st., Boston, near the Institute of Technology, out of 11 trials on different days, ·03798 to ·04999, and on one day (April 1), ·03194; in Clarendon Place, near Berkely st., ·03371. According to the same experimenter, the volume of carbonic acid in the air of a recitation room of the Institute, after recitation, [we omit the date], was found to be ·08929 to ·09762 p. c.; in a small "weighing room" of same, ·13041 to ·13205; in the Myrtle st. Grammar School, ·13431 to ·13659; in the Tremont st. id., ·14335; the Richmond st. id., ·17781; in the Blossom st. id., ·19037; in the Appleton st. Primary School, ·11092; in the Cooper st. id., ·19927; in Music Hall, Tremont st., ·14045; in the Public Library waiting room, on three different days, each, ·13666, ·13747, ·19352.—*Second Ann. Rep. Mass. State Board of Health,* 1871.

3. *Report of the Board of Health of the City of Chicago for* 1867, 1868, *and* 1869, *and a Sanitary history of Chicago from* 1833 to 1870. 332 pp. 8vo. Chicago. 1871.—The officers of the Board, are Samuel Hoard, President; John H. Rauch, M.D., Sanitary Superintendent and Registrar of Vital Statistics; Ambrose Burnam, Health Officer; J. W. Russell, Secretary. The report is illustrated with diagrams and maps, and is an exceedingly important contribution to the subject. The diagrams show that the period of highest mortality at Chicago during the years 1867, 1868 and 1869, was between the 20th of July and 1st of September; and that the period of increase began late in June or very early 1st of July.

4. *Effect of the Eclipse on the Magnetic Needle;* by D. MULLER, (Gaz. offic. del Regno d'Italia).—On the 22d of December the magnetic needle followed its usual course till the commencement of the eclipse. It then retraced its steps until it reached its minimum declination at $1^h\ 58^m$, which was the instant of totality. From that moment the ascending motion toward the west began anew, until the needle had regained the exact position it had occupied when the eclipse began.—*Athen.*, Feb. 18.

5. *Establishment of Paul Mohr in Ohio for the sale of fossils and minerals.*—This establishment has been opened at Bantam, Clermont Co., Ohio. Mr. Mohr, of Vienna, is in communication with various European houses, and states that he can furnish specimens or collections at low rates.

6. *Corrosion of Lead pipes.*—A paper on this subject, by Wm. Ripley Nichols, is contained in the 2nd Ann. Rep. of the Mass. State Board of Health, 1871.

7. *Chemical Society.*—Prof. FRANKLAND has succeeded Prof. Williamson as President of the Chemical Society.

OBITUARY.

LARTET, the discoverer of human relics and remains in caves and Quaternary formations in France, the principal author of the *Reliquiæ Aquitanicæ*, and an active member of the French Institute, died in the department of Gers, during the investment of Paris. He was Professor of Paleontology at the Museum of Natural History, filling the place left vacant by the death of d'Archiac.

BECQUEREL, the physicist, died in Normandy during the siege of Paris, at the age of eighty.

GUILLAUME LEJEAN, Secretary of the Geographical Society of France and author of various Geographical papers, has recently died.

HAIDINGER, of Vienna, the veteran mineralogist, crystallographer and physicist, and the most active promoter of scientific progress in Austria, died in the latter part of the month of March.

Catalogue of Minerals with their Formulæ and Crystalline Systems; prepared for the use of the students of the School of Mines, of Columbia College; by THOMAS EGGLESTON, Prof. Min. and Met. 2nd ed., 42 pp. 8vo. New York, 1871.

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[THIRD SERIES.]

ART. LVI.—*On Jupiter and its Satellites*; by MARIA MITCHELL, Professor of Astronomy in Vassar College. (With a plate.)

THE observations referred to in the following notes were made at a time when the mechanism of the instrument in use was receiving improvements, and the records are therefore those of eye estimates and not of accurate measurements. They do not, however, rest wholly on my own impressions. Separate drawings and estimates were made in several cases by three of my students, Misses Abbot, Glover, and Mead, and my own were checked by theirs.

The characteristics of the phenomena seen on Jupiter's disc in the Fall of 1870 and the Winter of 1870–71 differed from those of the preceding year. The rosy tinge of the equatorial belt was less marked; the dark spots on the same belt were less decided, and the white spots more numerous. In the notes of Jan. 9, 1870, I use the expression "very rosy" in describing the upper edge of the broad belt; words which I could not use in regard to the color, at any time of observation since that date.

The instrument used was the large Equatorial telescope, the object-glass of which is 12½ inches in diameter.

The oval marking given in fig. 1 was seen Jan. 19, 1870. It is without doubt the same seen by Prof. Mayer at an earlier date.

It is at least a singular coincidence, that a group of small spots on the sun, arranging themselves in the same figure, is recorded on Jan. 22. I record on June 18, 1870, a rosy tinge on the extreme northern edge of Saturn's ring; the night being remarkably good.

Nov. 1, 1870.—Two shadows and one satellite were seen at once on Jupiter's disc. The satellite, which was the first, was faint, brown, and ill defined, when first seen; near the center of the planet, its shape was oval. A large spot could be seen on the fourth satellite.

Nov. 10, 1870.—The narrow southern dark belt has a violet tinge.

Nov. 16, 1870.—A short and broad violet marking was seen near the northern border.

Nov. 28, 1870.—The broad equatorial belt could be seen out to the following edge. There were three large white spots upon it. The third satellite was warmer in tint than the other three.

Dec. 3.—The broad belt was seen again, quite out to the following limb. The first satellite was seen on the planet near the preceding limb, of dazzling whiteness, resembling the polar regions of Mars. White spots were noticed on the broad belt. The fourth satellite seemed to have a halo around it.

Dec. 10, 1870.—I began early to watch for the entrance of the first satellite and its shadow. The planet was low and the air full of tremor. I lost the satellite at once, when it entered upon the planet, and did not see it until 8 P. M., when I found it near the center of the disc. It seemed to be round and was dusky in color. Only twelve minutes later, this round figure had enlarged and become an irregular oval figure, stretching into the broad equatorial belt; it was then very distinct. As the shadow and satellite were thrown upon the planet nearly at the same time, it is probable that they were seen together, but there was no distinction of color. It seemed as large as the third satellite plus about its third. The whole shrunk suddenly, and then disappeared a few minutes after 9 P. M., and at 9^h 32^m P. M. the satellite reappeared, still on the planet, round and very white. At 10^h 5^m the broad dark equatorial belt was seen out to the following edge. I have given the changes of the first satellite in figs. 3 and 4. No inequality of brightness could be detected in the bright belt along which the course of the satellite lay.

Dec. 16, 1870.—The noticeable peculiarities are, the continuance of the dark equatorial belt quite out to the limb of the planet, both preceding and following, but more strongly in the latter case, and the unequal brightness of the southern bright belt, presenting in a coarse way something of the appearance of the sun's disc. The third satellite was brighter at the center than at the edges.

Jan. 7, 1871.—A very marked phenomenon is represented in figs. 5 and 6. A white oval spot was seen preceded by two brownish spots at 6^h 57^m. It was afterwards seen only by glimpses, until $7^h 36^m$ when it reappeared, but with a change of relative position; it was then between the brown spots. The shadow of the second satellite, very black at first, dimmed as it came to the center, and became elongated.

Jan. 13, 1871.—Two white spots seen near the northern edge seemed to change in relative position in the course of half an hour.

Jan. 16, 1871.—The passages of the first satellite and of the shadow were carefully watched. The satellite was seen through nearly the whole transit; it was lost for about 20 minutes when near the center—at this time the shadow became elongated. When the shadow entered upon Jupiter, it seemed to have a penumbra around it, and to be preceded by a small white spot. A large white spot was seen above the most northern dark belt.

Jan. 19, 1871.—Three large white spots were seen on the dark equatorial belt. The third satellite was on the planet and was smaller than any one of these spots.

In watching the changes of Jupiter's bright cloudy belts or of its dark bands, one is continually reminded of the changes in the sun's photosphere. Although the variations are less marked on Jupiter than on the sun, yet it is true of both, that drawings made at intervals of half an hour would show different relations of dark and light spots.

The changes in the satellites seem to me peculiar. I have watched the first satellite a good deal, and while I have never seen it enter upon, or leave the disc as other than a white circular object, either I have lost it at the center, or it has changed in shape and color,—becoming elongated toward the polar regions, and assuming a reddish-brown hue. The impression made upon the observer is that of the interposition of some medium through which it is seen dim and distorted.

ART. LVII.—*On the Physical Constitution of the Sun;* by Professor W. A. NORTON.

AMONG the recent theories of the Physical Constitution of the Sun, based on the later discoveries, astronomical and spectroscopic, that propounded a few years since by M. Faye* has been most favorably received. It is an essential feature of this theory that the sun's mass consists wholly, or in a great degree of gases or vapors; and that a process of interchange of solar matter between the interior and the photosphere is in incessant operation, in ascending and descending currents, by which the solar radiation is maintained. In a paper by J. Homer Lane, on the Theoretical Temperature of the Sun, &c., published in this Journal, July, 1869, it is elaborately argued, and appears to be successfully maintained, that the great rapidity of circulation required by this theory cannot subsist consistently with the received laws of gaseous circulation. Quite recently another theory of the sun's physical constitution has been propounded by Professor F. Zöllner of Leipzig; based mainly on the well established fact that the solar protuberances, conspicuously visible in total eclipses, and observable at all times with the aid of a spectroscope, are most of them due to violent eruptions of masses of incandescent hydrogen.* He remarks that "it is impossible, without passing beyond the well known analogies necessary for the explanation of cosmical phenomena, to assign any other cause to these eruptions than the difference of pressure of the gases emanating from the interior and from the surface of the sun. To make such a difference of pressure possible it is necessary to admit the existence of a separating stratum between the inner and outer strata of hydrogen—the latter of which, as is well known, forms an important portion of the solar atmosphere. In reference to the physical constitution of this stratum, we must furthermore assume that it cannot be gaseous, and must therefore be either solid or liquid." He remarks further, that "with regard to the inner masses of hydrogen bounded by that stratum, two suppositions are possible, viz: 1. The whole interior of the sun is filled with incandescent hydrogen gas, which would make the sun an immense bubble of hydrogen surrounded by a liquid glowing envelope. 2. The masses of hydrogen, bursting out into protuberances, are local collections in bubble-like caverns, which form in the superficial layers of a liquid glowing mass, and burst through when the pressure of the confined gas increases." Prof. Zöllner adopts the latter supposition as the more probable of the two.

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* Comptes Rendus, vol. lx, pp. 89 and 138.

This theory may furnish an adequate supposable cause for the observed eruption of incandescent masses of hydrogen, but its fundamental hypotheses have no secure ground to rest upon. The notion, that the sun's photosphere is in the liquid state, is irreconcilable with the astonishing rapidity with which changes often occur on the sun's surface, and also with the fact that the vast elevated masses, seen as the faculæ, occasionally retain the same position for several days; and though suggested long since, has not, to my knowledge, been adopted by any astronomical observer. No hypothesis of the possible origin of the sun's spots, upon this idea, has been framed that affords a satisfactory explanation of even their more conspicuous features and phenomena. To this remark the theory advanced by Prof. Zöllner, viz: that "the nucleus of the solar spots is a scoriaceous product of local cooling on a liquid surface, and the penumbræ clouds of condensation, which surround at a certain height the coasts of these islands of slag, offers no exception." It is not new, and has been already overthrown by the investigations of M. Faye.* The other fundamental hypothesis of Professor Zöllner's theory of the physical constitution of the sun, viz: that the masses, which burst out into protuberances, are local collections in bubble-like caverns, which form in the superficial layers of a liquid glowing mass, does not derive any support from analogical facts. It must be regarded as a pure hypothesis, unsustained by any inherent probability, or by any known fact, other than that which it is framed to explain. Besides, an hypothesis which brings the hydrogen in eruptive, or streaming masses, to the sun's surface, does not suffice. Another arbitrary hypothesis is required to dispose of the hydrogen which has thus been accumulating above the sun's photosphere for an indefinite period of time.

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* Journal of the Franklin Institute, Nov., 1870; also Philosophical Magazine, Nov., 1870.

Such being the state of the case with regard to the recent attempts to discover the secret of the sun's physical constitution, in the light of the late remarkable discoveries, we seem to be in this dilemma; whatever conception is formed of the condition of the sun's photosphere—whether liquid or gaseous—it appears to be contradicted by received principles, or controverted by established facts. We are thus naturally led to suspect that either some physical cause has been hitherto left out of account, which plays an important part in solar phenomena, or else the conception adopted of the mechanical condition of the solar vapors is radically at fault. It appears to me that good and sufficient reasons may be urged that will justify both these grounds of suspicion; and that a new point of view may be gained from which we may obtain a deeper insight into the physical processes in operation on the sun.

It is a little remarkable that it should have been hitherto assumed that the facts and laws of Terrestrial Physics can alone furnish a true philosophical ground for a theory of Solar Physics; and that no serious attempt should have been made to obtain additional light from known processes in operation on a cosmical scale in the regions of space. There is a class of bodies, some of which in their periodical excursions through the fields of space approach quite near the sun, and which are in general conspicuously subject to influences of a powerful nature exerted by the sun, besides the force of gravitation. It certainly seems natural to expect that these cosmical bodies might give us some insight into the nature of the forces in operation at the sun's surface. It is assuredly too late to urge that the transformations which they undergo under the sun's influence are wholly involved in mystery; for it has certainly been satisfactorily established that a portion of the cometary matter becomes subject to a *solar repulsion*, and is urged away by this force with a high velocity, and to great distances from the sun, and that this repulsion augments in intensity as the comet approaches the sun.* Now if such an energetic force of repulsion emanates from the sun, and operates on cometic matter at all distances, both small and great, according to the law of inverse squares, there is assuredly a high probability that it may play an important part on that vast arena, where solar forces are obviously engaged in fierce contention. It may be conjectured that the solar vapors are entirely different substances from, and wholly unlike, in their physical state, the cometary vapors that appear to be so exceedingly subtil. But it is certainly more philosophical to suppose that the same substances, or substances possessed of the same general properties, are present in all cosmical bodies, and the earth. Besides we are not without direct evidence on this point. Huggins, by examining the spectrum furnished by the light emitted from the Comet II, 1868, detected the presence of the vapor of carbon in the brighter portions of the comet. "He has been able to discriminate between the light of the nucleus of a comet and that of its tail. The nucleus is self-luminous, and its substance is in the form of ignited gas. The coma shines by reflected light as clouds do."

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* Comptes Rendus, vol. lxi, p. 1089.

If, as is now conceded by astronomers, the tail of a comet is made up of matter detached from the general mass of the comet, by reason of a repulsive action exerted by the sun, it must also be admitted that the matter expelled is not all urged away by the same intensity of force, and with the same velocity; for we find that it is much more widely dispersed in the plane of the cometary orbit than is consistent with this supposition. For example, I have shown, in my theoretical discussion of Donati's Comet,† that if we conceive particles of matter to have been expelled from this comet, with a certain small lateral velocity, and urged away during a certain interval of time by a solar repulsion bearing to the force of gravitation the ratio of

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* This is generally, if not universally, admitted by astronomers. The author has undertaken in former numbers of this Journal, to establish by rigorous calculation that the luminous train of Donati's comet was developed by a force of solar repulsion coöperating with the attraction of gravitation—both varying according to the law of the inverse squares. (See this Journal, vol. xxxii.)

† This Journal, II, vol. xxxii, pp. 54–66.

1·213 to 1, they would, at the end of the interval, have been found distributed over a narrow band coincident, at its forward line, with the curved preceding side of the tail of the comet; and that the other portions of the tail must have been composed of matter subject to various degrees of solar repulsion less than this. In fact the definite conclusion was in this way reached that the preceding half of the tail consisted of matter repelled from the sun with a force varying between the limits 1·213 and 0, and that the following half was for the most part composed of matter detached from the comet simply by reason of a weakened gravitation toward the sun,—the intensity of the force of gravitation along the following side of the tail being 0·455. There would seem then to be no alternative but to admit that the tail of Donati's comet was composed of different substances, (or else of one substance in different physical states) subject to a repulsive action from the sun of various degrees of intensity; and either prevailing over the sun's attraction of gravitation, or partially counteracting it, and so giving rise to an effective repulsion for certain of these substances, and to a diminished gravitation for others. The simplest theoretical explanation that can be given of this state of things is to suppose that the *solar repulsion consists of a series of impulses propagated in waves through the ether of space, and taking effect upon atoms of different sizes with varying intensity.* It is obvious that if this be true, the smaller the atom the more effective should be the repulsion as compared with the gravitating force soliciting the atom; since the ratio of the two forces should be proportional to the surface divided by the volume of the atom,—assuming that the mass is proportional to the volume, or that all atoms have the same density. We are thus incidentally led to infer that the larger comets consist of a variety of substances, like the earth.

The question now arises what can be the origin of the force of solar repulsion. There is another side of the diversified picture presented by cometary transformations under the sun's influence, which gives some intimations on this point. Not only is a certain portion of the cometary matter repelled by the sun, but it is also repelled by the nucleus of the comet. We see in large comets, a series of envelopes rise at intervals from the nucleus, on the side turned toward the sun, and recede at a nearly uniform rate until they become dissipated by the sun's repulsion. Luminous jets also stream out at times from the same side of the nucleus. These phenomena, it can hardly be doubted, are in some way the effect of the sun's heat. The simplest and most probable conclusion is that the ejecting force which is brought into play by the sun's heat is the direct repulsive energy of the heat received by the comet. We are thus led to infer that *the repulsive action exerted by the sun upon matter in the state of the cometary vapors, probably consists, either wholly or partially, in repulsive impulses propagated in the heat waves proceeding from the sun.*

Let us now see whether any confirmation of these inferences, and any additional light in the direction of our present inquiry, can be obtained on the substantial ground of Terrestrial Physics. The definite question presented for consideration, is whether the results of observation or experiment afford any indication of a direct repulsive action exerted by radiant heat on the atoms of bodies. It is universally admitted that radiant heat, when imbibed by a body, acts as a repulsive or separating agency among its molecules. It is also conceived that the conduction of heat is by radiation from atom to atom. The most natural inference from these facts is that the waves of radiant heat, which pass from atom to atom, directly urge the atoms away from each other by repulsive impulses. Instead, however, of adopting this simple idea, physicists have generally been inclined to refer the expansion of bodies from heat to some mode of motion of the atoms, originated by the heat received; though no detailed satisfactory explanation has yet been given of the manner in which such motions would directly originate an expansion. Strangely enough this notion is even entertained by physicists who regard heat as the only cause of the repulsion subsisting among the molecules of bodies. It should here be noted, that if the expansion of all bodies of matter from heat is to be ascribed to a direct impulsive, or repulsive action of heat waves proceeding from one atom and falling upon the surrounding atoms, then this force takes effect at the greatest distances by which the atoms are separated in the rarest gas under the feeblest pressure; and we would thus be led to expect that heated bodies in contact with each other might manifest signs of repulsion.

In point of fact, many evidences of a heat repulsion subsisting between particles of different bodies, in contact or in close proximity, have been adduced by different experimentalists, and writers on physics, some of which may be briefly mentioned.

1. "When pure silica, in an extreme state of division is highly heated, the slightest motion then causes the particles of the powder to slide over each other, and the surface of the powder is thrown into undulations almost like those of a liquid."

2. A rise of temperature is attended with a decrease of capillary attraction. Also the frictional resistance to the flow of water in pipes is diminished by heat.

3. "The spheroidal state of liquids is a complicated result of four distinct causes. The most influential is the repulsive force which heat exerts between objects which are closely approximated to each other."*

4. The vibrations of heated metals, as shown in "Trevilyan's Instrument," or "rocker," resting on a block of metal, are probably due to the direct repulsive force of heat, as maintained by Professor Forbes, of Edinburgh, in opposition to Faraday, who conceived that they were attributable to the sudden expansion by heat of the body on which the rocker rests. Faraday's explanation of these curious phenomena is adopted by Tyndall, who endeavors to overthrow Prof. Forbes's theory. His experiments serve to disclose the fallacy of certain features of the theory, but do not dislodge the fundamental idea that the phenomena are due to a force of heat-repulsion. This might be made apparent if we had space for a statement of the general principles on which the explanation rests, and for a detailed discussion of the results of the experiments.

Let us now consider if any sufficient evidence exists of a general force of molecular repulsion in operation at all temperatures,—beyond the sphere of sensible adhesion, or cohesion. We need, in fact, to look no farther for this than to the simple fact that in the ordinary contact of bodies the interval of distance between them, minute as it is, much exceeds the range of the attraction of cohesion, or adhesion; for in such contact the weight of the upper body is counteracted by a repulsion between the molecules about the point of contact. Dr. Robison has shown in his System of Mechanical Philosophy, that if two glasses, one slightly convex, the other flat, are placed on each other and pressed by a force of 1000 pounds to the square inch, they are still at the distance from each other of the thickness of the top of a soap bubble just before it bursts, or at least $\frac{1}{4456}$th of an inch. In effecting this contact there was no evidence of any attraction existing at distances greater than that at which the contact occurred. A similar remark may be made with regard to all cases of the apparent contact of homogeneous substances under a moderate pressure. It is only by increasing the pressure more or less, that the contiguous particles can be brought within the range of their reciprocal attraction of cohesion. When the particles are readily displaced among themselves under the direct action of a pressure, or blow, as in the case of soft or malleable substances, a permanent union may be effected without difficulty between the surfaces; that is, the outer repulsion of some of the particles may be overcome, their attraction of cohesion brought into play at the reduced distance, and an equilibrium established at the neutral point between this attraction and the inner repulsion. This occurs in the welding of iron.

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* Miller's Physics, p. 285.

Other evidences of an effective repulsion in operation between the molecules of bodies in contact, or in close proximity, are cited in treatises on Physics; although it is not always distinctly recognized that the sphere of its action lies entirely without that of the effective molecular attraction. Now what is the range of this *effective* repulsion between bodies. It obviously extends only to a small distance. Cavendish's well-known experiment has established that, when bodies are separated by considerable distances they tend toward each other by the attraction of gravitation. But are we therefore to conclude that the repulsive action, so energetic at the near approach of the molecules, has vanished altogether when they are a considerable distance apart. Is it not more probable that this force is confined to the surface molecules, and disappears at moderate distances, in comparison with the attraction of gravitation which is the result of the action of the entire masses on each other, because it decreases according to the inverse squares of the distance between the surfaces instead of the distance between the centers. I have elsewhere shown* that the force of gravitation cannot be the attraction of cohesion operating at considerable or great distances. It is a force *sui generis*, entirely distinct from the forces of molecular attraction and repulsion in operation at minute distances, and determining the constitution of bodies and their mechanical properties; and operates in conjunction with, but independently of, these molecular forces.†

In view of the concurrent testimony that we have now seen is afforded by the two departments of Cometary, and Terrestrial Physics, it will be admitted that, in attempting to gain a new insight into the physical constitution of the sun, and the processes of change in operation on its surface, we are at least entitled to assume the following as probable hypotheses.

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* Philosophical Magazine, vol. xxxviii. p. 38.

† It ought here to be stated, that in my paper on Molecular Physics published in this Journal, vols. xxxviii, xxxix and xl. I have deduced from the fundamental conception of a primitive molecule (or chemical atom) adopted, a force of molecular repulsion operating beyond the sphere of the molecular, or cohesive attraction; and reached the conclusion that this force has its immediate origin in the physical change to which the development of heat is in every instance due, viz: an inward or contractile vibratory movement of the electric envelopes by which all atoms are conceived to be surrounded, as well as by ethereal atmospheres. It is accordingly termed the molecular heat-repulsion. The repulsive energy of heat in operation on any molecule, is the sum of all the ethereal impulses developed by such movements of the envelopes of other molecules, (whether originating in the attraction exerted by the central atoms on their envelopes, or in an external collision or pressure), and propagated to the molecule. From the principle of interception of wave-force it results that the external repulsive action exerted by a solid body is confined to the surface molecules; while a force of heat-repulsion is propagated to an indefinite distance from all the molecules of a gas.

1. That the sun exercises a repulsive action upon the molecules of every gas or vapor that subsists at its surface, or is at any time in any part of the region of space exterior to the surface; that this force is the sum of all the heat impulses propagated in ethereal waves from all the gaseous molecules posited above the solid or liquid body of the sun, and from the surface molecules of this central mass, except in so far as these impulses may be intercepted in their passage; and that it is opposed to the force of gravitation, which is due to a virtual attraction of the sun's entire mass,—so that the effective force soliciting any gaseous molecule is the difference between these two forces, attractive and repulsive, by which it is urged.

2. That the force of solar repulsion, since it consists of impulses propagated in ethereal waves, is comparatively more effective in proportion as the atomic weight of the solar vapor is less; it being assumed that the quantity of matter in any atom is proportional to its volume.

3. That in a hypothetical condition of equilibrium of the sun's atmosphere the elastic force of each of its vaporous constituents, at any depth, will consist in the intensity of the effective heat impulses tending to urge its molecules outward; which will be counteracted by the weight of the superincumbent portion of the atmosphere. Now, let us assume, for the moment, that at some anterior epoch in the sun's history, all the present vaporous constituents of the sun's atmosphere were diffused throughout a space exterior to the central body of the sun and limited by the spherical surface (A), at which the molecules of the vapor of greatest atomic weight are in equilibrium, under the action of their own weight and of the heat-repulsion urging them upward. This hypothetical state of things could not continue, since the atoms of each of the other solar vapors would be urged upward by an effective force. If we conceive a small quantity of each of them to escape from all points of this surface, the rising vapors will ascend to greater heights in proportion as their atomic weights are less, and finally, when the equilibrium is attained, form a series of spherical envelopes, wholly detached from each other, and arranged in the order of atomic weights;—beginning with the heavier metallic vapors, and terminating with the lighter (potassium, sodium, &c.), and the permanent gases, with hydrogen outermost. If other small portions of each of the vapors were to rise from the surface, A, they would serve to augment the thickness of the envelopes already formed; and the same would be true for each successive discharge. The final result would be the same if the discharge were continuous during a certain interval of time, as

would naturally happen. After a certain amount of the solar vapors have escaped, contiguous envelopes might interpenetrate each other more or less. What it is especially important to observe, is, that *throughout the whole depth intercepted between each envelope, and the outer limiting surface,* A, *of the vapor of greatest atomic weight, every atom of the substance of which the envelope is composed, that may chance to be present, is urged upward by a force of repulsion.* If, as we must suppose, the rise of the solar vapors from the surface, A, continues for an indefinite time, the interpenetration of contiguous envelopes would increase, and eventually a condition of equilibrium would be attained; if the sun's temperature remained the same. But if this temperature were to increase, as it must down to a certain epoch in the process of consolidation, the process above indicated would be continually renewed. It is still more important to observe, that if there were any cause in operation withdrawing continually at short intervals a portion of one or more of these rising vapors, a statical equilibrium would not be reached; and it would be permanently true that *for every such vapor there would be a region of repulsion*, as above stated, *extending from its envelope down to the outer limit,* A, *of the vapor of greatest atomic weight.* Throughout this region the vapor would be perpetually rising, taking the place of that which is withdrawn, and so maintaining a *dynamical equilibrium.* The depth of this region would be the greatest for hydrogen, the outermost gas (unless there is some solar vapor of less atomic weight than hydrogen). Now it is easy to see that a certain physical cause tending to produce such results, must come into operation at some stage of the sun's process of consolidation. As conceived by Faye, the cooling going on at the outer surface must eventually bring the temperature there down to the point at which the vapors having the highest affinity for oxygen will undergo combustion. The products of such combustion, being compound molecules, will have a greater weight in comparison with the repulsion to which they are exposed, than the simple molecules before the combination took place, and hence they will descend, more or less rapidly, into the depths of the photosphere. To all appearance the sun is now passing through this period of its physical history, as supposed by Faye; and in the "granulations" which give to the solar disc a mottled appearance (Herschel's "subsiding chemical precipitates,") we probably discern the products of the combustion occurring in the upper photosphere and determining its outer limit, in the act of descending. The continual upward flow from the depths of the photosphere, of the hydrogen, oxygen, and the lighter metallic vapors, will bring about the necessary intermixture of oxygen with the other vapors. This must occur below the natural outer limit of the hydrogen envelope; and we know that as a matter of fact, the chromosphere, composed chiefly of hydrogen, extends above the photosphere.

If the products of the surface combustion were all to descend indefinitely into the vaporous photosphere, without undergoing decomposition, no farther visible effects would ensue. We could only follow with the mind's eye the gradual growth of the central nucleus of the sun, and recognize that we probably have before us a picture of the process by which the materials of the earth's crust were fashioned and accumulated in the earlier ages of its history. But the probability is that the descending masses would eventually arrive at a depth where the higher temperature would effect a dissociation of the combined elements (as Faye supposes). This must inevitably happen unless the tendency of the heat, that augments with the depth, is counteracted by the opposing tendency of the increasing gaseous pressure. By reason of these opposing tendencies it may well happen that there may be a certain region of dissociation of limited depth, above and below which decomposition would not occur. But it is to be observed that it does not follow that all of the products of surface combustion as they pass through such a region would be decomposed; since the reduction of temperature attending every instance of decomposition tends to prevent decomposition of other surrounding masses in the act of descending.

This sudden dissociation of large masses of combined elements, though occurring at certain depths within the photosphere, it will be seen may eventually play a conspicuous part at the surface. Unless the region of dissociation should lie below that of repulsion for the elements separated, these elements after separation will be urged upward by the effective force of repulsion, ascend rapidly, and emerge with a high velocity above their respective envelopes. The ascensional velocities attained will be greater if large masses are suddenly decomposed. The masses of hydrogen set free should attain to the greatest velocity, and rise to the greatest height. They should rise, in eruptive masses, above the hydrogen envelope, or in other words, the chromosphere. According to Lockyer, in the solar protuberances, the ascending hydrogen has in some cases, a velocity as high as 120 miles per second, and rises to a height of more than 40,000 miles.

A vertical jet of hydrogen, having a projectile velocity of 120 miles per second, should attain an altitude of 43,000 miles, if the solar gravity were constant for that altitude. Some prominences have extended to a height of 100,000 miles above the sun's photosphere. Prof. Respighi, has even noticed instances of an elevation of 160,000 miles. Such enormous heights imply either a greater initial velocity than 120 miles per second, or that the full energy of the solar attraction does not take effect on the eruptive masses of hydrogen, in the region above the photosphere. From our theoretical point of view, we perceive that the latter supposition should be true; since the solar repulsion should be in operation above the hydrogen envelope, or the chromosphere, diminishing the gravitating tendency.

The metallic vapors set free in the region of dissociation, should rise to heights varying with their atomic weights. Some of them, especially the lighter ones (sodium, magnesium, calcium, &c.), may acquire velocities sufficient to bring them above the chromosphere. In fact the spectroscope has detected besides hydrogen, magnesium, sodium, iron, and chromium, in the solar protuberances. Lockyer states that he has invariably found that in solar storms, the chromospheric layers are thrown up in the order of vapor density. He regards the chromosphere as built up of the following layers, which are in the order of vapor density in the case of known elements: a new element giving the green coronal line in the spectroscope, hydrogen, another new element, magnesium, sodium, barium, iron. He remarks that "all the heavier vapors are at or below the level of the photosphere itself."*

The green coronal line was traced in the late eclipse by Profs. Young and Winlock as far as 16′ or 425,000 miles from the sun's limb. From our present theoretical stand-point, we naturally infer, as Lockyer has already done from his observations, that the element present in the solar corona which gives this line is much lighter than hydrogen. We see also that an element several times lighter than hydrogen might be subject to a solar repulsion that would predominate over the attraction of gravitation at all distances, and urge the subtil vapor indefinitely away from the sun. Since the same line is seen in the light of terrestrial auroras, we must conclude that the same substance is present in our upper atmosphere;—either in a permanent upper layer, or derived from the sun (as I have elsewhere maintained). We must infer also that it is magnetic, which apparently cannot be the case unless it takes on the condition of compound molecules. Such compound molecules might become dispersed in the upper atmosphere of the earth, or in the photosphere of the sun, by electric discharges or sudden evolutions of heat; and then the separate atoms repelled off, forming the streamers of the corona and aurora, illuminated either by electric light, or in the case of the corona in part also by reflected solar light.[*]

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* It is admitted by Angström, and Zöllner, that the absence of spectroscopic indications of oxygen and nitrogen in the sun, is no sufficient evidence that these gases are really wanting in the sun's atmosphere.

The probable origin of the sun's spots, and other questions of solar physics that claim attention, must be left for future consideration. I will only remark here, that it has long been apparent that the diverse phenomena which occur at the sun's surface are traceable, more or less directly, to the action of some form of eruptive force. *The present investigation seems to have led to the discovery of the true nature and origin of this force; and at the same time to have revealed the process by which the sun's radiation is maintained.* The primary source of the solar heat being, doubtless, as now generally believed, the process of condensation maintained by the force of gravitation.

It is worthy of remark, in conclusion, that as comets directed our attention, at the outset, toward the sun, so the sun, in its turn, leads us back again to our starting point; since we see that if we transfer to cometary bodies the physical structure we have recognized in the sun's upper photosphere, viz: the existence of a succession of light vaporous envelopes, subject to the energetic action of the force of heat repulsion, the mystery in which some of the curious transformations they undergo, have hitherto been involved, seems to be in a great degree dispelled. No one doubts that comets are chiefly composed of very light vapors; though some of the larger ones may have a solid nucleus. If, as intimated, certain observed cometary phenomena indicate that these vapors, like the solar vapors, are arranged, for a certain depth at least, in envelopes, which are liable to be greatly expanded, or even wholly expelled by the increasing amount of heat received from the sun, we have in the probable physical structure of comets, another indication that these bodies were originally detached from the sun's photosphere, in addition to that furnished by certain features of the cometary motions.[†]

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[*] It is also conceivable that the subtil vapor streaming off in the coronal rays, has been set free by dissociation like the hydrogen, from some other element of a compound substance, in the depths of the photosphere. However this may be, it can hardly be doubted that the ascent and descent of the solar vapors, and the combinations and decompositions going on among them, must be attended with disturbances of electric equilibrium, from which decided effects must result.

[†] Norton's Astronomy, revised edition, p. 276.

ART. LVIII.—*On the Composition of Permanent Illuminating Gas obtained from the decomposition of Petroleum Naphtha*; by H. H. EDGERTON. With a prefatory note by B. SILLIMAN.

THE conversion of the light napthas resulting from the rectification of Pennsylvania petroleum into a permanent gas, suited for economical use as an illuminant, either by itself or when mixed with poor gas, or atmospheric air as a diluent, is a problem of no little importance; especially in view of the enormous volume of these light products, equal to at least one-eighth part of the total production of crude petroleum. A process for converting this volatile material into a permanent gas has been devised, and is coming into notice under the name of "Rand's process," which is in fact founded upon an invention patented some years since by Dr. L. D. Gale. In this process the vapor of naphtha evolved in a distillating apparatus by a steam coil is carried into an iron retort heated to redness where it is in great part converted into permanent gases of very high illuminating power. Small portions of the denser oils which escape destructive distillation are delivered by a syphon into a suitable receptacle; while the gas, after cooling, is carried to the holder and is fit for immediate use. It is so rich, however, in illuminants as to be unfit for use in common gas burners, and hence is usually reduced by admixture with atmospheric air, of which it requires about an equal volume to bring it to a standard of 25 candles by the photometer.

As this problem possesses considerable scientific interest, aside from its economical importance, I have requested Mr. H. H. Edgerton, Superintendent of the Gas works at Fort Wayne, Indiana, who is a well instructed and skillful gas chemist, to communicate for publication his analytical results upon the constitution of the naphtha gas, which are subjoined.

The "Memphis Gas" quoted in these analyses is the gas made at Memphis, Tennessee, by this method, that city being thus lighted. By "Fort Wayne N. Gas" Mr. Edgerton means the naphtha gas made by himself at Fort Wayne. In a letter Mr. Edgerton says he has calculated the gases which are not absorbed by Nordhausen acid as methyl or marsh gas, and the absorbable gases as $C_4H_4 + C_8H_8$, although he adds, "I am convinced these gases do not co-exist, but go to form an intermediate gas, of less simple relation of volumes."

The economical details of this interesting research are given in a separate form elsewhere. It will be a source of great satisfaction should this method of utilizing light naphtha become an established industry, since in this manner alone can we hope, by consuming the raw material, to avoid those constantly recur-ing disasters from the use of "dangerous kerosene," made dangerous by the fraudulent addition of these volatile hydrocarbons, by reason of which many hundreds of lives are annually sacrificed. B. S.

Constituents of Naphtha Gas reduced to 100 *volumes.*

"*Memphis Gas.*"

Hydrocarbon illuminating gases,	25·42
Marsh gas,	34·16
Methyl,	3·29
Nitrogen,	32·24
Oxygen,	4·89
	100·00

"*Fort Wayne Gas.*"

		1st analysis.		2d analysis.	
Ethyl (Olefiant gas),	C_4H_4,	37·54	55·81	38·28	55·81
Ditetryl (Butylene),	C_8H_8,	18·27		17·53	
Marsh gas,	C_2H_4	13·98	44·19	13·98	44·19
Methyl,	$(\overset{2\text{ vol.}}{C_2H_3}\ \overset{4\text{ vol.}}{C_4H_6})$	30·21		30·21	
		100·00		100·00	

Condensation of Hydrocarbons absorbable by concentrated Sulphuric acid. In analysis of Memphis gas.

Gas employed,	41·47	of which	7·143	absorbable by SO_3
Less Nitrogen,	13·37		20·957	non-absorbable.
Combustible gas,	28·10			

According to previous analysis, due non-absorbable gases.

	Due non-absorb.	Vol. absorb.	Due absorb.	Per vol.
Carbonic acid,	22·80	7·143	19·40	2.716
Oxygen used,	52·136		21·50	3·010
Contraction,	50·293		7·21	1·009

Fort Wayne Naphtha Gas.

Gas employed, 6·819, of which 55·81 pr. ct. absorb. Vol. 3·806.

	Due non-absorb.	Per vol.	Due absorb.	Per vol.	Total.
Carbonic acid,	5·073	1·683	10·103	2·654	15·176
Oxygen used,	9·081	3·013	15·604	4·100	24·685
Contraction,	7·023	2·339	9·129	2·398	16·152

Second trial.—Gas employed, 7·000, of which

	Non-absorbable.		Absorbable.		Total.
	3·093	per vol.	3·907	per vol.	
Carbonic acid,	5·208	1·683	10·260	2·626	15·468
Oxygen used,	9·321	3·013	16·204	4·147	25·525
Contraction,	7·210	2·339	9·381	2·401	16·591

Analyses of Petroleum Naphtha Gas, February and March, 1871.

	V.	V. KO	V. Pyro gal.	V. SO 3HO	CO₂ Pr. ct.	O Pr. ct.	Hydro-carb. Pr. ct.	R. V.	R. V. +air.	O added.	N added.
Memphis Gas,*.....	167·18	167·18	160·66	118·13	None.	4·91	25·42	21·13	217·03	280·67 2·08	162·90
" " †.....	41·47	....	....	....	....	....	....	....	541·40	104·78	395·15
Ft. Wayne N. Gas,‡	193·15	193·15	192·36	107·81	None.	0·41	55·81	13·49	210·51	41·29	155·71
" " " §	....	....	....	....	....	....	....	19·46	351·16	69·52	262·17
" " " ‖	....	Bunse	n's met	hod.	....	....	....	19·59	252·93	269.90 48·91 16·96	184·43
" " " ¶	7·36	....	....	...	....	....	....	....	144·76	28·80	108·61
	7·21	....	....	....	...	....	....	....	184·02 119·29	37·06	139·75
" " " **	....	....	....	....	....	....	....	6·56	119·07	23·58	88·93

TABLE OF ANALYSES—continued.

	After explosion.	R. V. KO	R. V. Pyro-gal.	R. V. +H	R. V. 2d explosion.	R. V.—RN	CO₂ found.	O used.	C contracted.	For 1 or 100 volumes. CO₂	O	C
Memphis Gas,*...	249·28	235·05	....	608·88	392·41	13·08	14·23	32·54	31·39	....	....	....
" " †...	483·90	441·70	408·51	....	....	28·10	42·20	73·63	57·50	....	....	....
Ft. Wayne N. Gas,‡	180·34	158·56	156·26	....	....	12·94	21·79	39·00	30·16	1·68	3·01	2·33
" " " §	308·41	277·31	263·76	....	....	17·88	31·10	55·97	42·75	1·74	3·13	2·39
" " " ‖	230·76	205·76	....	347·41	293·89	16·21	25·00	48·03	39·14	1·63	3·18	2·55
" " " ¶	128·17	112·70	108·95	....	....	7·00	15·47	25·04	16·59	2·21	3·29	2·37
	167·87	152·20 152·70	....	188·57	151·16	6·819	15·18	24·68	16·15	....	....	....
" " " **	106·11	97·09	....	133·82	112·78	5·461	9·018	16·522	13·186	1·651	3·025	2·414

V.=Volume. R. V.=Residual Volume. R. V.—RN=Residual vol. employed after deducting N found.

* Memphis gas before going into "air mixer," supposed to be pure Naphtha gas.

† To find condensation of absorbable hydrocarbons.

‡ Yielded from commercial benzine at rate of 80 cubic feet per gallon.

§ Analysis of residual gas from same after standing over water.

‖ Another trial of residual gas after absorption of illuminating gases, the absorption made on a quantity contained in a glass holder; sp. gr. of same by Bunsen's diffusion method ·779.

¶ Combustion of same gas (No. 5, second series) before absorbing hydrocarbons to ascertain condensation—two trials.

** Analysis of residual gas after passing No. 5 through Liebig bulbs containing bromine, through water and caustic potash solution. Weight taken before and after of each:

	Before.	After.		
Bromine,....	52·402	67·760	Weight of hydrocarbons absorbed,	4·788 grams.
Water,.....	95·580	106,220	Vol. of gas passed,..............	Lost.
Potash,.....	74·770	53·550	" " residual gas,............	201·06 cub. in.
	222·752	227·530		
		222·752		
		4·778	Sp. gr.,........................	·796

These analyses agree in the main, that one volume of absorbable gas forms on explosion 2⅔ vol. of carbonic acid, and the illuminating power, compared with olefiant gas, is one-third greater, or as 1 to 1⅓, according to Mr. Lewis Thompson's rule. The sp. gr. of hydrocarbons, found by an indirect method, was 1·271. The candle-power of the Fort Wayne gas would be, therefore, according to the chemical standard 74·41 candles, or 5 to 6 times that of ordinary coal gas. The actual candle-power by photometric test is much higher.

The analyses were all made (with one exception) with Prof. Frankland's apparatus. Owing to a disproportion of parts, the "laboratory tube" being exceedingly small, holding only one-third contents of measurer, but a very small quantity of gas could be analyzed,—about ½ c. c. when nitrogen was present. To give an idea of the experimental error on so small a quantity, four analyses of *air*, by electrolytic H are added.

1st.		2d.	
Air emp. (expanded vol.)	62·5	Air emp. (unex. vol.)	6·877
After H,	125·9	After H,	14·519
After explosion,	87·3	After explosion,	10·182
⅓C=12·87 per ct.	O=20·59	⅓C=1·4457 per ct.	O=21·023

3d.		4th.	
Air employed,	14·827	7·547	
After H,	30·088	14·790	
After explosion,	21·028	10·496	
⅓C=3·020 per ct.	O=20·368	⅓C=1·431 per ct.	O=18·969

Fort Wayne, Indiana, March 20, 1871.

ART. LIX.—*A Historical Note on the Method of Least Squares;* by CLEVELAND ABBE, A.M.

IT is well known that the "Method of Least Squares," although first published in printed form by LeGendre in 1806, in his "Nouvelles Methodes," was first invented by Gauss as early as 1795, and had for years been taught by him in his lectures to his students at Göttingen. It was, however, some years before the Gaussian method came into general use, and especially were English scholars very slow to acquaint themselves with its merits. I have, therefore, been much interested in finding that, in 1808, Professor Robert Adrain, at that time in New Brunswick, N. J., published the method of least squares in the "Analyst," having been independently led to this invention by the study of a prize problem offered some months previously in that periodical.

As the editor of, and chief contributor to, the Mathematical Correspondent, the Analyst, and the Mathematical Diary, and as Professor in Columbia College and in Pennsylvania University, as well as by his correspondence, Dr. Adrain is well known to have contributed powerfully to the progress of Mathematical studies in this his adopted country—(he was born and educated in Dublin)—and his apparently independent demonstration of the method of least squares seems quite in accordance with the originality shown in many other of the elegant solutions offered by him to the different problems on which he busied himself. A number of interesting and probably valuable mathematical manuscripts still remain in the possession of his family at New Brunswick, New Jersey, which it is to be hoped may some day see the light. At present I would offer toward the history of mathematics in America the following extracts from the Analyst and other publications.

The problem "to correct the distances and bearings of a survey, so as to deduce the most probable area of the enclosed field," had been proposed by Professor Patterson in a previous number of the Analyst, and after being a second time renewed as a prize question, was at length in number IV, solved by a course of special reasoning, by Dr. Bowditch, to whom Dr. Adrain awarded the prize. Dr. Bowditch's results coincided with what would have been deduced had the Gaussian method been applied to this case. Immediately following Dr. Bowditch's special solution, the editor adds his own solution of the more general problem as follows: (The Analyst, pp. 93–95 inclusive).

"*Research concerning the probabilities of the errors which happen in making observations.*"

"The question which I propose to resolve is this: supposing AB to be the true value of any quantity of which the measure by observation or experiment is A*b*, the error being B*b*; what is the expression of the probability that the error B*b* happens in measuring AB?

Let AB, BC, &c., be several successive distances of which the values by measure are A*b*, *bc*, &c., the whole error being C*c*; now supposing the measures A*b*, *bc*, to be given and also the whole error C*c*, we assume as a self-evident principle, that the most probable distances AB, BC are proportional to the measures A*b*, *bc*; and therefore the errors belonging to AB, BC are proportional to their lengths, or to their measured values A*b*, *bc*. If therefore we represent the values of AB, BC or of their measures A*b*, *bc* by a, b, the whole error C*c* by C, and the errors of the measures A*b*, *bc* by x, y, we must for the greatest probability, have the equation $\frac{x}{a}=\frac{y}{b}$. Let X and Y be similar functions of a, x, and of b, y, expressing the probabilities that the errors x, y happen in the distances a, b; and, by the fundamental principle of the doctrine of chance, the probability that both these errors happen together will be expressed by the product XY. If now we were to determine the values of x and y from the equations $x+y=\mathrm{E}$ and $\mathrm{XY}=$maximum, we ought evidently to arrive at the equation $\frac{x}{a}=\frac{y}{b}$: and since x and y are rational functions of the simplest order possible of a, b and E, we ought to arrive at the equation $\frac{x}{a}=\frac{y}{b}$ without the intervention of roots, in other words by simple equations; or, which amounts to the same thing in effect, if there be several forms of X and Y that will fulfill the required condition we must choose the simplest possible, as having the greatest possible degree of probability.

"Let X′, Y′ be the logarithms of X and Y, to any base or modulus; and when $\mathrm{XY} = max.$ its logarithm $\mathrm{X}' + \mathrm{Y}' = max.$ and therefore $\dot{\mathrm{X}}' + \dot{\mathrm{Y}}' = 0$, which fluxional equation we may express by $\mathrm{X}''\dot{x} + \mathrm{Y}''\dot{y} = 0$; for as X′ involves only the variable quantity x, its fluxion $\dot{\mathrm{X}}'$ will evidently involve only the fluxion of x; in like manner the fluxion of Y′ may be expressed by $\mathrm{Y}''\dot{y}$; and from the equation $\mathrm{X}''\dot{x} + \mathrm{Y}''\dot{y} = 0$ we have $\mathrm{X}''\dot{x} = -\mathrm{Y}''\dot{y}$: but since $x + y = \mathrm{E}$ we have also $\dot{x} + \dot{y} = 0$, and $\dot{x} = -\dot{y}$, by which dividing the equation $\dot{\mathrm{X}}''\dot{x} = -\dot{\mathrm{Y}}''\dot{y}$, we obtain $\mathrm{X}'' = \mathrm{Y}''$.

"Now this equation ought to be equivalent to $\frac{x}{a} = \frac{y}{b}$; and this circumstance is effected in the simplest manner possible, by assuming $\mathrm{X}'' = \frac{mx}{a}$, and $\mathrm{Y}'' = \frac{my}{b}$; m being any fixed number which the question may require.

"Since, therefore, $\mathrm{X}'' = \frac{mx}{a}$ we have $\mathrm{X}''\dot{x} = \dot{\mathrm{X}}' = \frac{mx\dot{x}}{a}$, and taking the fluent, we have $\mathrm{X}' = a' + \frac{mx^2}{2a}$. The constant quantity a' being either absolute, or some function of the distance a.

"We have discovered, therefore, that the logarithm of the probability that the error x happens in the distance a is expressed by $a' + \frac{mx^2}{2a} = \mathrm{X}'$, and consequently the probability itself is $\mathrm{X} = e^{\mathrm{X}'} = e^{\left(a' + \frac{mx^2}{2a}\right)}$. Such is the formula by which the probabilities of different errors may be compared, when the values of the determinate quantities e, a' and m are properly adjusted. If this probability of the error x be denoted by u, the ordinate of a curve to the abscissa x, we shall have $u = e^{\left(a' + \frac{mx^2}{2a}\right)}$, which is the general equation of *the curve of probability.*

"When only the maximum of probability is required, we have no need of the values of e, a' and m; it is proper, however, to observe that m must be negative. This is easily shown. The probability that the errors x, y, z, etc., happen in the distances a, b, c, etc., is $e^{\left(a' + \frac{mx^2}{2a}\right)} \times e^{\left(b' + \frac{my^2}{2b}\right)} \times e^{\left(c' + \frac{mz^2}{2c}\right)}$, etc., which is equal to $e^{\left(a' + b' + c', \text{ etc.}, + \frac{mx^2}{2a} + \frac{my^2}{2b} + \frac{mz^2}{2c}, \text{ etc.}\right)}$, and this quantity will evidently be a maximum or minimum as its index or logarithm is a maximum or minimum; that is, when

$$\frac{m}{2}\left\{\frac{x^2}{a} + \frac{y^2}{b} + \frac{z^2}{c}, \text{ etc.}, \right\} = \text{a maximum or minimum.}$$

Now when $x + y + z$, etc., $=$ E, we know that

$$\frac{x^2}{a} + \frac{y^2}{b} + \frac{z^2}{c}, \text{ etc.}, = \text{minimum, when } \frac{x}{a} = \frac{y}{b} = \frac{z}{c}, \text{ etc.},$$

and therefore $-\left\{\frac{x^2}{a} + \frac{y^2}{b} + \frac{z^2}{c}, \text{ etc.}, \right\} = \text{maximum.}$

When $\frac{x}{a} = \frac{y}{b} = \frac{z}{c}$, etc., it is evident therefore that m must be negative; and as we may for the case of maxima use any value of it we please, we may put $m = -2$, and the probability of x in a is $u = e^{\left(a' - \frac{x^2}{a}\right)}$. If we put $\frac{m}{2a} = -1$ and $a' = f^2$, we have $u = e^{(f^2 - x^2)}$ for the equation of the curve of probability; but if we suppose $f^2 = 0$, the ordinates u will still be proportional to their former values, and we shall have $u = e^{-x^2}$, or $u = \frac{1}{e^{x^2}}$, which is the simplest form of the equation expressing the nature of the curve of probability."

Immediately following the above general solution by Dr. Adrian there are given applications of this method to the following problems.

1. To find the most probable value of any quantity of which a number of direct measures are given.
2. To find a most probable position of a point in space.
3. To correct in the most probable manner the dead reckoning at sea.
4. To correct the bearing and distances of a field survey.

The article closes on p. 109 of the Analyst with the following: "I have applied the principles of this essay to the determination of the most probable value of the earth's ellipticity, &c., but want of room will not permit me to give the investigation at this time."

The investigations here alluded to were, however, long afterwards published, i. e., in 1817, in vol. i, new series, of the Transactions of the American Philosophical Society, and are given in two papers (Nos. IV and XXVIII) of that volume. The preceding note as well as the dates written on the manuscripts (which are still preserved by the Hon. G. B. Adrian of New Brunswick) show that these two investigations were completed in 1808.

The first of the papers here alluded to is entitled "Investigation of the figure of the earth and of the gravity in different latitudes," from which as printed in the Phil. Trans., we make the following extract:

"Having in the year 1808 discovered a general method of resolving several useful problems by ascertaining the highest degree of probability, when certainty cannot be found, I shall here apply that method to the determining of the earth's ellipticity, &c." The author's computation is based on the lengths of the seconds pendulum as given by Laplace (Mec. Cel., iii), and having stated the problem before him, he says: "This is accomplished by a rule published by the writer in the Analyst, in 1808." The resulting ellipticity ($\frac{1}{319}$) he shows to differ from that deduced by Laplace ($\frac{1}{379}$) because of numerical errors in the computation of the latter; having corrected these he deduces the ellipticity $\frac{1}{319\cdot5}$ by Laplace's own method—showing that the two methods conduce to nearly the same result.

The second of the articles in the Phil. Trans., is entitled "A Research concerning the Mean Diameter of the Earth." In this the author seeks the sphere which most nearly coincides in various specified peculiarities with the actual terrestrial spheroid; the diameter of this sphere he determines to be 7918·7 miles. This numerical result is based upon some earlier computations, the details of which are not given, but of which he says: "Having determined the most probable axis of the terrestrial spheroid from the measurements of a degree of the meridian by a method which I discovered several years ago and published in the Analyst, the resulting mean radius was found to be 3959·69 English miles."

The mathematical works published by Dr. Adrian are so rarely to be met with, that it was necessary to make these long extracts in order to establish the conclusion to which we have arrived, i. e., that we must credit Dr. Adrian with the independent invention and application of the most valuable arithmetical process that has been invoked to aid the progress of the exact sciences.

Washington, Feb. 22, 1871.

Art. LX.—*Contributions to Chemistry from the Laboratory of the Lawrence Scientific School.* No. 15.—*On some new Analytical Methods;* by Thomas M. Chatard.

§ 1. *On the Determination of Molybdic Acid as Plumbic Molybdate.*

Great difficulty has always been experienced in determining molybdenum by any of the methods generally in use. The precipitation as mercurous molybdate, and the subsequent treatment, are both tedious and unsatisfactory, and an accurate determination as sulphide is almost impossible, the filtrate remaining blue even after repeatedly passing sulphydric acid and filtering.

The following method will, I hope, be found to give satisfaction, both as to ease of working and accuracy of results.

Add to the boiling solution of the molybdate, plumbic acetate in slight excess. Boil for a few minutes; the precipitate, at first milky, will become granular and will subside easily, leaving a perfectly clear supernatant liquid. Care must be taken in boiling, as the thick milky fluid is very apt to boil over. A ribbed filter is to be used and the precipitate is to be washed with hot water. The washing proceeds with great ease and thoroughness, and not the slightest milkiness should be apparent in the filtrate. The precipitate is dried at 100°, separated from the filter and ignited in a porcelain crucible.

The results were as follows:

1·0744	grm. Na_2MoO_4 gave	1·9176	grm. $PbMoO_4$	= 46·64	p. c. Mo.
1·4440	" " " "	2·5738	" "	= 46·60	" "
1·2221	" " " "	2·1811	" "	= 46·66	" "
1·2871	" " " "	2·2999	" "	= 46·74	" "

Mean = 46·66.

The theoretical percentage of Mo in Na_2MoO_4 is 46·60 if Mo = 96, this being the number given by the most recent determinations.

The process seems therefore to give very good quantitative results, and is both easy and expeditious. The precipitated molybdate separates easily from the filter and can be heated to low redness without decomposition.

Analogy would seem to offer a good method for tungstic acid and experimental analyses were made for this purpose, but after repeated trials the process was finally abandoned, as the precipitate came down so finely divided that it passed through the filter. The precipitation seems, however, to be complete, and I have hopes that with closer filter paper greater success will be obtained.

Attempts were made to determine arsenic as arsenate of lead but without good quantitative results. On the other hand

I tried to determine lead as molybdate, tungstate, and arsenate, but without success, as the presence of an excess of the precipitant in such cases seems to exert an injurious effect, the filtrate or washings speedily becoming cloudy.

It may not be out of place to mention some work upon molybdenum undertaken some time ago, which, though unsuccessful, is not without interest. Various methods were devised of weighing the molybdenum as sulphide.

One way was to precipitate molybdic acid as mercurous molybdate in the usual manner. The suspended molybdate was boiled and sulphydric acid passed into the boiling liquid. The mercurous molybdate was decomposed and mercurous sulphide and molybdic sulphide were the results. The sulphides were thrown upon a filter and washed with cold sulphydric acid water, dried and ignited in a current of sulphydric acid, but this process failed to give satisfactory results.

Again, sodic molybdate was heated with four parts of dry sodic hyposulphite till all the free sulphur was driven off, leaving, according to theory, $Na_2SO_4+MoS_3$. The mass was then digested with hot water, filtered and treated as before. When any of the sulphur was left, it was found that some of the molybdenum went into solution as sulphomolybdate of sodium. Even after adopting every precaution, enough was still dissolved to vitiate the analysis.

§ 2. *On the Evaporation to dryness of Gelatinous Precipitates.*

In a former paper* I called attention to the fact that many gelatinous precipitates, when evaporated to dryness, became very granular and easy to filter. I gave some examples then and have since tested several others.

Titanic Acid.—Rutile was fused with sodic disulphate, the titanic acid precipitated by ammonic hydrate and evaporated to dryness. It became quite sandy and washed with great rapidity and thoroughness.

Glucina.—Pure glucina was dissolved in chlorhydric acid, precipitated by ammonic hydrate and evaporated to dryness. In this case as glucina is soluble in ammoniacal salts, it was necessary to ignite the dry mass to expel these. This was done in the platinum dish in which the evaporation was carried on. The residual glucina was sandy and washed with great ease; *zirconic*, *niobic* and *tantalic acids* when thus treated gave results which were all that could be desired.

Ceric, lanthanic and didymic oxalates when treated with sulphuric acid, and ammonic hydrate added, gave also perfectly satisfactory results.

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* This Journal, vol. l, p. 247.

In conclusion, there seems to be no doubt that almost any gelatinous precipitate can be successfully treated in this manner.

§ 3. *Tests for Nitrous Acid.*

During the course of some work on the nitrites of nickel and cobalt, it was necessary to have an easy and accurate test for nitrous acid. I therefore reviewed all the tests given for that acid, comparing their relative degrees of delicacy, with the following results. For testing, a very dilute solution of Fischer's salt, $(Co_2 6NO_2 + 6(KNO_2) + 2Aq)$, which contained $\frac{1}{300000}$ part by weight of nitrous acid, was employed.

Schönbein's* test with a weak solution of indigo decolorized by potassic sulphide failed to give accurate results. Besides there are many substances which would have the same action upon the decolorized indigo as the nitrous acid.

C. D. Braun's† test with cobaltous chloride and potassic cyanide gave no reaction with so dilute a solution, even when several cubic centimeters were taken, the reaction only appearing when a comparatively strong solution of the nitrite was used.

Hadow's‡ reaction in which a nitrite when heated with potassic ferrocyanide and mercuric chloride forms nitroprussic acid which is detected by an alkaline sulphide, gave good results only when the nitrous acid was present in larger quantities, not being delicate enough to give a reaction with the standard solution of nitrite which I employed.

A modification of this test suggested itself, in which the nitroprussic acid is thus produced. To the solution suspected of containing the acid, potassic ferrocyanide and acetic acid are added, and the whole boiled. The solution is allowed to cool, and ammonic sulphide added. If nitrous acid was originally present, the characteristic blue reaction will appear. 10 c.c. of the test solution gave the reaction, but it failed with a smaller quantity.

The problem was finally solved by another reaction, namely, the production of phenol from aniline by means of nitrous acid. Evaporate the test liquid nearly to dryness, then rub it with a few drops of a strong solution of sulphate of aniline. If nitrous acid is present the odor of phenol will immediately result. This test is remarkably delicate, 1 c. c. of the test solution giving a perfectly distinct reaction. Nor can nitrous be confounded with nitric acid, as this last produces no phenol, but merely a yellow color, which of itself, as is well known, is of value as a test for that acid.

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* Jahresbericht, 1864, 699.

† Ibid. 1865, 702.

‡ Jour. Chem. Soc., vol. iv, p. 341.

§ 4. *On the Determination of small quantities of Manganese.*

The delicacy of Crum's test for manganese is well known, but it is believed that no attempt has hitherto been made to employ it as a method of quantitative determination. The following work was, therefore, undertaken with that view.

A standard solution of ammonic oxalate was prepared, of which 1 c. c.=0·0005467 grm. Mn. A sample of dolomite was taken, and four portions were weighed out. These were dissolved in nitric acid, and a small quantity of plumbic peroxide added to each. On boiling, the bright color of hypermanganic acid appeared. The solutions were passed through small filters of asbestos with the aid of a Bunsen's pump, and the hypermanganic acid was determined by means of a standard solution of ammonic oxalate with the following results:

3·1300	grm.	dolomite	required	39·0	c. c.	= 0·0216	grm.	Mn	= 00·069	p. c.	Mn
2·781	"	"	"	33·2	"	= 0·0181	"	"	= 00·065	"	"
2·0998	"	"	"	24·5	"	= 0·0134	"	"	= 00·063	"	"
1·8671	"	"	"	23·5	"	= 0·0128	"	"	= 00·062	"	"

Mean = 00·065 p. c. Mn.

In a sample of limestone from White Horse, Chester, Co., Pa. the analysis showed

3·4316	grm.	required	120	c. c.	= 0 0656	grm.	Mn	= 1·92	p. c.	Mn.
2·2809	"	"	83·5	"	= 0·04564	"	"	= 2·00	"	"
4·0697	"	"	153·5	"	= 0·0838	"	"	= 2·05	"	"

Mean = 1·99 p. c. Mn.

But the method, though giving good results where the percentage of manganese is small, fails when any large amount of that metal is present. Well dried manganous pyrophosphate was treated with sulphuric acid, as nitric acid, though dissolving it, was found not to decompose it, little or no hypermanganic acid being formed when the plumbic peroxide was added. With sulphuric acid, the red color of hypermanganic acid was produced, but it was found that not even long boiling sufficed for total oxydation.

This was also the case with an alloy of iron and manganese. The longer it was boiled, the more hypermanganic acid was formed, but there seemed to be no definite limit. No concordant results having been reached, and a well marked end reaction in such cases being hard to obtain, the method as applied to general analysis was given up.

There seems to be, however, reason to maintain that when the quantity of manganese is very small, the method will be found both easy and accurate. Perhaps by some modification of the process, it may be made to apply also to the cases in which large quantities of manganese are present.

In conclusion, I desire to acknowledge my indebtedness to Dr. W. Gibbs for his careful supervision and many valuable suggestions.

Cambridge, March 1, 1871.

ART. LXI.—*On the Oil-bearing Limestone of Chicago;* by T. STERRY HUNT, LL.D., F.R.S.

(Read before the American Association for the Advancement of Science at Troy, August, 1870.)

WHEN in 1861,* I first published my views on the petroleum of the West, I expressed the opinion that the true source of it was to be looked for in certain limestone formations which had long been known to be oleiferous. I referred to the early observations of Eaton and Hall on the petroleum of the Niagara limestone, to numerous instances of the occurrence of this substance in the Trenton and Corniferous formations and, in Gaspé, in limestones of Lower Helderberg age. Subsequently, in this Journal for March, 1863, and in the Geology of Canada, I insisted still further upon the oleiferous character of the Corniferous limestone in southwestern Ontario, which appears to be the source of the petroleum found in that region. I may here be permitted to recapitulate some of my reasons for concluding that petroleum is indigenous to these limestones, and for rejecting the contrary opinion, held by some geologists, that its occurrence in them is due to infiltration, and that its origin is to be sought in an unexplained process of distillation from pyroschists or so-called bituminous shales. These occur at three distinct horizons in the New York system, and are known as the Utica slate, immediately above the Trenton limestone, and the Marcellus and Genesee slates which lie above and below the Hamilton shales; the latter being separated from the underlying Corniferous limestone by the Marcellus slate.

First, these various pyroschists do not, except in rare instances, contain any petroleum or other form of bitumen. Their capability of yielding volatile liquid hydrocarbons or pyrogenous oils, allied in composition to petroleum, by what is known to chemists as destructive distillation, at elevated temperatures, is a property which they possess in common with wood, peat, lignite, coal, and most substances of organic origin, and has led to their being called bituminous, although they are not in any proper sense bituminiferous. The distinction is one which will at once be obvious to all those who are familiar with chemistry, and who know that pyroschists are argillaceous rocks containing in a state of admixture a brownish insoluble and infusible hydrocarbonaceous matter, allied to lignite or to coal.†

Second, the pyroschists of these different formations do not, so far as known, in any part of their geological distribution, whether exposed at the surface or brought up by borings from depths of many hundred feet, present any evidence of having been submitted to the temperature required for the generation of volatile hydrocarbons. On the contrary they still retain the property of yielding such products when exposed to a sufficient heat, at the same time undergoing a charring process by which their brown color is changed to black. In other words these pyroschists have not yet undergone the process of destructive distillation.

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* Montreal Gazette, March 1, and Can. Naturalist, July, 1861.

† This Journal, II, xxxv, 159–161.

Third, the conditions which the oil occurs in the limestones, are inconsistent with the notion that it has been introduced into these rocks by distillation. The only probable or conceivable source of heat, in the circumstances, being from beneath, the process of distillation would naturally be one of ascension, the more so as the pores of the underlying strata would be filled with water. Such being the case, the petroleum of the Upper Silurian and Lower Devonian limestones must have been derived from the Utica slate beneath. This rock, however, is unaltered, and moreover, the intermediate sandstones and shales of the Loraine, Medina and Clinton formations are destitute of petroleum, which must, on this hypothesis, have passed through all these strata to condense in the Niagara and the Corniferous limestones. More than this, the Trenton limestone which, on Lake Huron and elsewhere, has yielded considerable quantities of petroleum, has no pyroschists beneath it, but on Lake Huron rests on ancient crystalline rocks, with the intervention only of a sterile sandstone. The rock-formations holding petroleum are not only separated from each other by great thicknesses of porous strata destitute of it, but the distribution of this substance is still further localized, as I many years since pointed out. The petroleum is in fact in many cases, confined to certain bands or layers in the limestone, in which it fills the pores and the cavities of fossil shells and corals, while other portions of the limestone, both above, below, and in the prolongation of the same stratum, though equally porous, contain no petroleum. From all these facts the only reasonable conclusion seems to me to be that the petroleum, or rather the materials from which it has been formed, existed in these limestone rocks from the time of their first deposition. The view which I put forward in 1861, that petroleum and similar bitumens have resulted from a peculiar "transformation of vegetable matters, or in some cases of animal tissues analogous to these in composition," has received additional support from the observations of Lesley,* in West Virginia and Kentucky, and from the more recent ones of Peckham.†

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* Rep. Geol., Canada, 1866, 240, and Proc. Amer. Philos. Soc., x, 33, 187.

† Ibid, x, 445.

The objections to this view of the origin and geological relations of petroleum have been for the most part founded on incorrect notions of the geological structure of southwestern Ontario, which has afforded me peculiar facilities for studying the question. In this region, it has been maintained by Winchell that the source of the petroleum is to be sought in the Devonian pyroschists. I however showed in 1866, as the result of careful studies of the various borings: first, that none of the oil-wells were sunk in the Genesee slates, but along denuded anticlinals where these rocks have disappeared, and where, except the thin layer of Marcellus slate sometimes met with at the base of the Hamilton shales, no pyroschists are found above the Trenton limestone. Second, that the reservoirs of petroleum in the wells sunk into the Hamilton shales are sometimes met with in this formation, and sometimes, in adjacent borings, only in the underlying Corniferous. Examples of this have been cited by me in wells in Enniskillen, Bothwell, Chatham and Thamesville, where petroleum has first been found at depths of from thirty to one hundred and twenty feet in the Corniferous limestone, in all of these places overlaid by the Hamilton shales. It was also shown, that in two localities in this region, viz., at Tilsonburg and in Maidstone, where the Corniferous is covered only by quaternary clays, petroleum in considerable quantities has been obtained by sinking into the limestone.* That the supplies of petroleum in such localities are less abundant than in parts where a mass of shales and sandstones overlies the oil-bearing limestone is explained by the fact that both the pores and the fissures in the superior strata serve to retain the oil, in a manner analogous to the quaternary gravels in some parts of this region, which are the sources of the so-called surface oil-wells. It is, therefore, not surprising that examples of pyroschists impregnated with oil should sometimes occur, but the evidence of the existence of indigenous petroleum, which is so clear in the various limestones, is wanting in the case of the pyroschists; although concretions holding petroleum, have been observed in the Marcellus and the Genesee slates of New York. There is, however, reason to believe, as I have elsewhere pointed out, that much of the petroleum of Pennsylvania, Ohio, and the adjacent regions, is indigeneous to certain sandstone strata in the Devonian and Carboniferous rocks.†

At the meeting of the American Association for the Advancement of Science at Chicago, in August, 1868, in a discussion which followed the reading of a paper by myself on the geology of Ontario,‡ it was contended that, although the various limestones which have been mentioned are truly oleiferous, the quantity of petroleum which they contain is too inconsiderable to account for the great supplies furnished by oil-producing districts, like that of Ontario for example. This opinion being contrary to that which I had always entertained, I resolved to submit to examination the well-known oil-bearing limestone of Chicago.

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* This Jour. II, xlvi, 360; and Report Geol., Canada, 1866, pp. 241–250.

† Ibid. 240.

‡ This Jour. II, xlvi, 355.

This limestone, the quarries of which are in the immediate vicinity of the city, is so filled with petroleum that blocks of it which have been used in buildings are discolored by the exudations, which mingled with dust, form a tarry coating upon the exposed surfaces. The thickness of the oil-bearing beds, which are massive and horizontal, is, according to Prof. Worthen, from thirty-five to forty feet, and they occupy a position about mid-way in the Niagara formation, which has in this region a thickness of from 200 to 250 feet. As exposed in the quarry, the whole rock seems pretty uniformly saturated with petroleum, which exudes from the natural joints and the fractured surfaces, and covers small pools of water in the depressions of the quarry. I selected numerous specimens of the rocks from different points and at various levels, with a view of getting an average sample, although it was evident that they had already lost a portion of their original content of petroleum. After lying for more than a year in my laboratory they were submitted to chemical examination. The rock, though porous and discolored by petroleum, is, when freed from this substance, a nearly white, granular, crystalline and very pure dolomite, yielding 54·6 p. c. of carbonate of lime.

Two separate portions, each made up of fragments obtained by breaking up some pounds of the specimens above mentioned, and supposed to represent an average of the rock exposed in the quarry, were reduced to coarse powder in an iron mortar. Of these two portions, respectively, 100 and 138 grammes were taken, and were dissolved in warm dilute hydrochloric acid. The tarry residue which remained in each case, was carefully collected and treated with ether, in which it was readily soluble with the exception of a small residue. This, in one of the samples, was found equal to ·40 p. c., of which ·13 was volatilized by heat with the production of a combustible vapor having a fatty odor; the remainder was silicious. The brown etherial solutions were evaporated, and the residuum, freed from water and dried at 100° C., weighed in the two experiments equal to 1·570 and 1·505 per cent of the rock, or a mean of 1·537. It was a viscid reddish-brown oil, which, though deprived of its more volatile portions, still retained somewhat of the odor of petroleum, which is so marked in the rock. Its specific gravity, as determined by that of a mixture of alcohol and water, in which the globules of the petroleum remained suspended, was ·935 at 16° C. Estimating the density of the somewhat porous dolomite at 2·600, we have the equation ·935 : 2·600 : : 1·537 : 4·26; so that the volume of the petroleum obtained equalled 4·26 per cent of the rock. This result is evidently too low for two reasons; first, because the rock had already lost a part of its oil, while in the quarry and subsequently, before its examination: and secondly, because the more volatile portions had been dissipated in the process of extraction just described.

In assuming 100·00 parts of the rock to hold 4·25 parts by volume of petroleum, we are thus below the truth in the following calculations. A layer of this oleiferous dolomite one mile (5280 feet) square, and one foot in thickness will contain 1,184,832 cubic feet of petroleum, equal to 8,850,069 gallons of 231 cubic inches, and to 221,247 barrels of forty gallons each. Taking the minimum thickness of thirty-five feet, assigned by Mr. Worthen to the oil-bearing rock at Chicago, we shall have in each square mile of it 7,743,745 barrels, or in round numbers seven and three quarter millions of barrels of petroleum. The total produce of the great Pennsylvania oil-region for the ten years from 1860 to 1870 is estimated at twenty-eight millions of barrels of petroleum, or less than would be contained in four square miles of the oil-bearing limestone band of Chicago.

It is not here the place to insist upon the geological conditions which favor the liberation of a portion of the oil from such rocks, and its accumulation in fissures along certain anticlinal lines in the broken and uplifted strata. These points in the geological history of petroleum were shown by me in my first publications already referred to, March and July, 1861, and independently, about the same time, by Prof. E. B. Andrews in this Journal for July, 1861.*

The proportion of petroleum in the rock of Chicago may be exceptionally large, but the oleiferous character of great thickness of rock in other regions is well established, and it will be seen from the above calculations that a very small proportion of the oil thus distributed would, when accumulated along lines of uplift in the strata, be more than adequate to the supply of all the petroleum wells known in the regions where these oil-bearing rocks are found. With such sources existing ready formed in the earth's crust, it seems to me, to say the least, unphilosophical to search elsewhere for the origin of petroleum, and to imagine it to be derived by some unexplained process from rocks which are destitute of the substance.

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* This Journal II, xxxii, 85. See also papers on the subject by him and by Prof. Evans, Ibid. II, xl, 33, 334; and one by the author, II, xxxv, 170; also Report Geol. Survey of Canada, 1866, pp. 256–257.

ART. LXII.—*On the Geology of the Delta, and the Mudlumps of the Passes of the Mississippi;* by EUG. W. HILGARD.

[Continued from page 368.]

Origin of the Mudlumps.—The causes which give rise to the formation of mudlumps have been to some extent discussed by Sidell, Thomassy, and Lyell (*loc. cit.*). The former is inclined to ascribe the upheaval *chiefly* to the pressure of gas formed in the decay of driftwood and the like, buried in the river deposits. Thomassy resorts to the hypothesis of the existence of subterraneous channels communicating with the river, or with equally hypothetical reservoirs of water, far above; while Lyell ascribes the bulging of the bottom to the pressure of newly formed deposits upon a substratum of yielding mud, accompanied, and aided incidentally only, by the evolution of marsh gas in the decay of organic matter. I myself, having become aware of the existence of a strong artesian water pressure in the littoral formations of the Gulf, was inclined to ascribe the origin of the upheaving force to that source; and my visit to the mouths had for its object mainly, the comparison of the facts with each of the three admissible hypotheses, that of Thomassy being too fanciful to be seriously entertained.

As already stated, I at once found that the evolution of gas in the active vents was too insignificant to be considered as the cause of the rising of the liquid mud, which so greatly exceeded it in bulk, that the ascensional force of the bubbles, especially in so wide a vent-tube, would be utterly inadequate to balance the downward tendency of so heavy a liquid. It might still be alleged, in favor of the gas-hypothesis, that its pressure might be exerted statically upon the surface of the mass of liquid mud covered by impervious strata; but it is obvious that in such a case, the gas itself, necessarily accumulating at the highest, and therefore weakest, points, of the superincumbent mass, would be much more likely to break through by itself, promptly exhausting its force and quantity at any one point. No such rushing outbreaks of gas have ever been recorded, save in the case of blowing up of a lump with gunpowder; and, as Lyell remarks, this view renders inexplicable the occurrence of lumps exclusively about the mouths of the passes.

The latter objection applies equally to the hypothesis of the artesian origin of mudlump force, unless upon the (unproved) supposition that the excavation of the river channel might have rendered the outbreak of the artesian water easier there than elsewhere. But instead of *excavating*, the Mississippi has for a long time past always thrown *shallows* in advance of its mouths; and unless it were conclusively proven that *the matters ejected by the mud-springs* were such as could not originate in the present delta formation, the artesian hypothesis must lose all show of probability. An accurate investigation of the matters in question, solid, liquid, and gaseous, was therefore indicated. A few specimens for this purpose were collected for me by Mr. Marindin, in 1867; but the perusal of his report accompanying them convinced me that a personal examination *in loco* could alone insure a perfect certainty as to their significance, and accordingly, in the autumn of the same year, I re-collected specimens from the same, as well as from other localities. Very unfortunately, the arrangements for gas analysis at my command were so imperfect that, while waiting for their improvement, the gas specimens were so vitiated by diffusion through corks and wax as to render them useless; and I have been unable to replace them as yet, but hope to do so in the near future.

Mudlump Gases.—The examination of the water and mud seemed, however, most likely to conduce to a solution of the problem, at any rate; for after all, the only information which could be furnished by gas analysis would be to indicate, by the greater or less amount of carbonic acid present, whether the gas originated from matter comparatively fresh and in its first stage of decomposition, or had its source in materials far advanced toward the stage of lignite or coals. The only perfectly reliable determination made was that of the carbonic acid contained in the gas collected from the most easterly active cone on Marindin's Lump, Passe à l'Outre, the rest of the determinations being somewhat vitiated, though doubtless very nearly correct.* The result was as follows:

Gas from East Crater, Marindin's Lump, Passe à l' Outre.

Carbonic acid,	9·41
Marsh gas,	86·20
Nitrogen,	4·39
	100·00

Oxygen was not present.

The percentage of carbonic acid in this gas is very unusually large; its composition is nearest to that of the gas from common swamps, where vegetable matter is in its first stages of decay. The proportion between marsh gas and nitrogen is nearly the same as in the gas from the gas wells at New Orleans (see p. 245); but there is three times as much carbonic acid present in the mud-lump gas, in accordance with the presumable more advanced stage of decay existing in the former locality.

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* After the explosion in the eudiometer, some nitrate of mercury was observed on its walls, in consequence of inadequate dilution of the gas. But the marsh gas was estimated from the carbonic acid absorbed after the explosion, the nitrogen by difference.

Mudlump Spring Waters.—In taking specimens, common quart bottles were filled by immersion in the craters themselves, and immediately sealed. The liquid mud thus obtained would, after a while, separate into a lower stratum of pretty solid mud, and an upper one of clear water, in varying proportions. For analysis, the latter was carefully decanted, and the turbid part rapidly filtered through a Bunsen's pressure filter, and measured. 400 ccm. were then boiled to precipitate carbonates and silica, the filtrate re-diluted to the original bulk, and from 50 to 100 ccm. used in the determination, in separate portions, of chlorine, of lime and magnesia, and of sulphuric acid and alkalies, respectively; while a fourth portion served for an approximate determination of the solid residue, for the sake of roughly controlling the final results.*

I give below, in tabular form, the results of these analyses; presented in three different forms, for the sake of ready comparison with the composition of sea-water, from which they seem to be derived by a series of reactions easily understood from the nature and condition of the materials with which they are associated.

I. Water from the basin of a spring on a mudlump off Stake Island, Southwest Pass. Evolves gas and water in about equal proportions, no mud, but only fine sandy matter; and water flows off clear over the rim of the basin, which is two feet above tide level, and at the foot of a large extinct cone with a lagoon, surrounded by a high rim, in the center.

Water about ¼ of the bulk in bottle, the rest fine sand. Taste, very salty; color, slightly yellowish; turns brownish turbid very quickly on exposure to air. Coll. Dec. 3, 1867.

II. Water from a mudlump spring on Northeast Pass, collected by H. L. Marindin, of U. S. Coast Survey schr. Varina, in February, 1867.

According to the recollection of one of the crew, this specimen was taken from the same cone as the following one (No. III).

Water clear, faintly yellowish, about ¼ by bulk of the contents; the rest sandy mud. Turns turbid rapidly on exposure to air.

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* With mixtures of this kind no method but that of evaporation with excess of carbonate of soda will yield anything more than an approximate estimate of the solid residue; involving an amount of labor and care not always justified by the end in view, when the relative amounts of ingredients can serve to control. The chlorine determination being the most accurate, and almost always in excess of the bases found available to form chlorides, the chloride of sodium, as here recorded, is the *calculated* amount, as is also the sum of ingredients.

Analyses of Waters from Mudlump Springs, Mississippi Passes.

	Southwest Pass.			Northeast Pass. Salt Spring Island.						Passe à l'Outre. Marindin's Lump.					
				February.			December.			East Crater.			West Crater.		
	I.			II.			III.			IV.			V.		
	a.	b.	c.	a.	b.	c.	a.	b.	c.	a.	b.	c.	a.	b.	c.
Chloride of Sodium,	2·5374	80·060	81·662	2·7847	81·937	84·117	2·7751	82·809	84·670	1·2439	79·094	85·857	1·7544	79·708	84·055
" Potassium,	0·0280	0·884	0·901	0·0441	1·297	1·332	0·0441	1·316	1·346				0·0166	0·754	0·795
" Calcium,	0·0725	2·287	2·388	0·0342	1·006	1·033	0·0638	1·903	1·947	0·0018	0·114	0·124	0·0649	2·947	3·109
" Magnesium,	0·4635	14·624	14·917	0·4475	13·168	13·518	0·3945	11·773	12·037	0·1962	12·475	13·543	0·1259	11·440	12·061
Sulphate of Calcium,	0·0007	0·022	0·023							0·0069	0·439	0·476			
" Magnesium,															
Carbonate of Calcium,	0·0011	0.035		0·0313	0·921		0·0001	0·003		0·0695	4·419		0·0230	1·045	
" Magnesium,	0·0446	1.407		0·0447	1·315		0·0724	2·160		0·0392	2·492		0·0745	3·385	
" Iron,	0·0158	0.499		0·0121	0·356					0·0119	0·757		0·0128	0·582	
Silica,	0·0007	0.022					0·0012	0·036		0·0033	0·210		0·0030	0·139	
	3·1643	99·840	99·891	3·3986	100·000	100·000	3·3512	100·000	100·000	1·5727	100·000	100·000	2·2010	0·06100	100·000
Specific Gravity,		1·02388			1·0244						1·01196			1·01689	

a. Ingredients in 100 ccm. of the water. b. Ingredients in 100 parts of solid residue. c. Ingredients in 100 parts of solid residue exclusive of carbonates and silica.

TABLE—continued.

	Knight's Gas Well. New Orleans. VI.			Gulf Water. 30 miles out. VII.		Sea Water. Average composition. VIII.	
	a.	b.	c.	a.	b.	a.	b.
Chloride of sodium,	0·02310	37·880	56·479	1·6723	76·870	2·700	77·032
" potassium,	0·00790	12·950	19·315	0·0357	1·640	0·070	1·997
" calcium,	0·00060	0·980	1·467				
" magnesium,	0·00630	10·330	15·404	0·2310	10·620		10·271
Sulphate of calcium,							
						0·360	
Bromide of magnesium,				trace.	trace.	0·002	0·058
Sulphate "	0·00300	4·920	7·335	0·1077	4·950	0·140	3·994
				0·1289	5·920	0·230	6·562
Carbonate of calcium,	0·01120	18·360				0·003	0·086
" magnesium,	0·00760	12·450					
" iron,							
Silica,	0·00130	2·130					
	0·06100	100·000	100·000	2·1756	100·000	3·505	100·000
Specific gravity,				1·01630		1·0298	

III. Water from faintly active cone on Salt Spring Island, off Northeast Pass; from crater on west side of island, about ten feet above sea-level. Collected Dec. 2, 1867.

Water very salty, about ⅘ of the whole mass; the rest, a somewhat sandy mud; color, slightly yellowish; turns turbid rapidly on exposure to air.

The larger proportion of water in this specimen, as compared with the preceding, doubtless results from the comparative inactivity of the cone, as compared to that at the time of high water in February. The same fact may account for some of the difference in composition.

IV. Water from East Crater on Marindin's Lump, Passe à l'Outre. See p. 362. Collected Dec. 2, 1867.

Forms about ⅗ of the bulk in the bottle, the rest is soft clayey mud. Faintly brownish, clear; becomes brownish turbid rapidly on exposure to air.

V. Water from West Crater on Marindin's Lump, Passe à l'Outre; same date.

Water about ½ of bulk in bottle, the rest clayey mud. Not very salty; colorless, but turns turbid quickly on exposure to air.

VI. Water from gas well bored by J. B. Knight, at New Orleans. Clear, with a little sand at bottom; taste, faintly brackish.

VII. Water of the Gulf of Mexico, taken from surface 30 miles out, southeast from Southwest Pass, Dec. 1867.

VIII. Average composition of sea-water, according to Regnault.

The general results deducible from the above analyses may be thus stated:

1. There is a general similarity of composition between the waters of the mudlump springs, indicating their derivation from a common source of supply. But springs on the same lump, as well as the same spring at different times or stages of water, may vary quite sensibly, both in composition and concentration. Their density is generally inferior to that of sea-water, though at times approaching it closely.

2. There is an obvious approximation of the ratio between the two chief bases—sodium and magnesium—to that existing in sea-water; the variations being no greater than are observed in sea-water from different localities.

3. The most obvious difference is the absence of sulphates, and their partial replacement by chlorides; also

4. The presence of large amounts of the carbonates of the earths, as well as of iron, dissolved in carbonic acid.

5. The amount of potassium salts is decidedly diminished.

6. Bromids appear to be entirely absent, and are present in traces only, in the water of the Gulf itself.

It is stated that the waters of some of the springs are fresh. I have found all brackish *at least*, and as the population of the delta is much in the habit of drinking water of questionable freshness, their judgment in the matter may not be the most reliable.

As regards the water of the New Orleans well, though at first sight it differs materially from the others, it will be observed that when in C, potassium and sodium chlorides are classed together, its composition becomes not unlike the mudlump waters. Its great dilution accounts for the excessive proportion of carbonates.

The Gulf water approaches very closely in its composition to the normal one of sea-water, as given by Regnault.

Mud from Mudlump Springs.—I have already stated, that the stratified material of the mudlumps (whether formed by the action of mud springs, or bodily upheaved) is free from visible shells or other fossils, save particles of woody matter; while the amorphous material which forms the surface and generally also the beach, often abounds in such organic remains as are now usually washed ashore, having manifestly been *cast* up and imbedded in the mud by the waves.

I have examined microscopically the mud remaining in the specimen bottles after decanting the water for analysis; they were immediately refilled with distilled water, and kept closely stopped until examined. I give below the record of examination of the mud, corresponding to analysis No. V, from West Crater on Marindin's Lump. Two or three others similarly examined gave a like result.

A sample from the general mass shows it to consist mainly of very fine quartz sand, mostly angular, with but a few large, angular grains; and but little true clay.

In washing the mass, even the first washings were found to contain but little clay, but chiefly very fine suspended silex. A few ill defined spicules, a Navicula, and bark fibers.

In the middle portion, spicules a little more abundant.

In the coarsest portion, much variously colored mica, along with, mostly sharply angular, quartz grains; numerous particles of water-browned wood; very distinct spine of a radiate; several specimens of Rotalina, and fragments of same as well as Uvigerina, Cristellaria, Amphistegina, and Coccineis? Also iridescent fragments, showing lines of growth, from the edges of larger bivalves.

Quartz grains mostly transparent and angular; some of milky, oil-green, and rose quartz; these mostly rounded. This sand resembles closely that of the bottom outside Northeast Pass bar, in 40 to 50 feet water; specimens of which were furnished me by the Coast Survey party, under command of Capt. F. V. Webber of the schooner Varina, in 1869.

Specimens from mudlumps on Southwest Pass show coarser sand, and rather more Foraminifera.

The character of the materials ejected by the mudlump springs, as determined by the foregoing investigations, may be summed up as follows:

1. The *gas* is such as is evolved by vegetable matter in its *first* stages of decay or lignitization.
2. The *earthy matter* contains both river and marine fossils—driftwood reduced almost to its cell-elements by maceration and trituration, as well as Foraminifera. Its fineness is such that, before final deposition, it may have been carried out into water of considerable depth.
3. The mudlump waters appear to be sea-water more or less diluted, and chemically changed under the joint influence of fermenting organic matter, and the more active ingredients of the river deposit, viz: carbonates of lime and magnesia, and oxide of iron.

The first effect thus produced would probably be the addition of the soluble carbonates of these metals to the solution. But the soluble sulphates could not, in the presence of a soluble iron salt, long resist the reducing influence of decaying organic matter. As usual under such circumstances,* iron pyrites would be formed, withdrawing in the end all the sulphuric acid from the solution, and forming, instead, equivalent amounts of the respective carbonates. The amounts of the chlorides of sodium and magnesium originally present would thus, also, be relatively increased; and this again tallies with the analytical results. Yet while the proportion between these bases is maintained* the actual *replacement* of sulphate of magnesium by the chloride constitutes a change not readily explained. At first sight it would seem that the excess of chlorine belonging to the chlorides of calcium and magnesium must be an outside accession; but our knowledge of the mutual reactions between the substances here present under strong pressure, is perhaps too fragmentary to justify an assertion on this point.

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* See Bischoff, Chemische Geologie, vol. i, p. 559.

The diminution of the potash salts is doubtless referable to their absorption by the clays present, in preference to all other compounds. The filtration of sea-water through soil would, according to Liebig's experiments, produce a like result.

Conclusions.—In view of the foregoing facts, the explanation of mudlump phenomena suggested, substantially, by Sir Chas. Lyell, seems the only tenable one; it requires, however, some modification as regards the mass supposed to exert the pressure, and some corollaries as to the mode of action.

I have before suggested, that the rapid protrusion of the mouths of the river into the Gulf, in advance of the body of the delta, is owing to the shelf of "blue clay bottom" extending, at a comparatively slight depth below the sea-level, and with a gentle slope, far out into the Gulf. It is upon this impervious clay that the present bars are based; and upon it, in advance of the bar, will be deposited the finest of the river mud, at a depth at which, perhaps, the sea-water is at the time quite undiluted, and fully adapted to marine life; which will therefore deposit its vestiges in it, associated with the finest particles of driftwood, etc. Mud thus deposited may remain unconsolidated for a great length of time, unless the water be drained off or through it by some means.

The bar, in its annual advance of about 338 feet, will cover over this liquid mud stratum, exerting a pressure much greater than that of the sea; and were it resting on a pervious bottom, the liquid mud would doubtless soon be consolidated into a sheet of clay. As it is, the tendency will be to squeeze it from under the crest of the bar, both seaward and landward. The very gradual seaward slope of the bar will render the movement in that direction a very slow one, under a greater depth of water and heavy frictional resistence. Not so on the land side, where, as the bar advances, the superincumbent pressure is measurably relieved by the erosion of a channel by the

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* The ratio is for

Atlantic sea-water,	30·5 : 3·0	Marindin's Lump water,	30·5 : 2·8 (min.)
German Ocean water,	30·5 : 4·0	Southwest Mudlump,	30·5 : 3·56 (max.)
Average sea "	30·5 : 3·4	Average of those analyzed,	30·5 : 3·1

current, which, especially in flood time, carries much of the bottom deposit bodily over the bar and drops it to seaward.* At weak points of the bottom inside the bar, therefore, the upward pressure of the mud may cause a bulging up at least to the level of the bar-crest, and, perhaps, taking into account the difference in the specific gravities of the comparatively solid bar and liquid mud, even as far as the surface of the water. But this, considering the question as coming within the domain of liquid statics, would seem to be about the extreme limit to which the bottom itself could be brought up.

I have found the specific gravity of the mud flowing from the West Crater on Marindin's Lump, to be about 1·25; that from the cone on Salt Spring Island, on Northeast Pass, 1·30; while that of bar deposit from the crest of the Northeast bar, wet as brought up by the lead, was 1·75. The heights of communicating columns of these substances, if sensibly liquid, should be as 5 to 7; but this ratio could apply, in the case of upheaval, only so far as the *difference* of level between the bar and the upheaved bottom is concerned, since the latter must be presumed to be similar to the bar in its materials and structure. Should the current, however, continue to denude the crest of the upheaved mass, the rising would continue and the semi-fluid mud might finally break through, forming a mudspring, the height of whose vent above its source might finally increase to the extent corresponding to the difference of specific gravity.

The craters of mudlumps have been sounded to the depth of 24 feet, but no precautions were used to insure reaching the actual maximum depth. In the borings made for the foundation of a lighthouse on the Southwest Pass, by Mr. A. Palms (the record of which was courteously forwarded to me by the Engineer Dept.), a stratum so soft that the augur sank in it by its own weight, was met with at 58 ft., after striking, at 56 ft. a stream of water which "filled the pipe."

If then, the mud stratum, lying, say 60 ft., below the surface, be pressed by a column of deposit of 1·75 sp. gr., mud of sp. gr. 1·25 could thereby be raised 24 feet above the top of the pressing column; and this, considering the average depth of water on the bar, would account for the greatest heights to which cones are built up off the mouths.

But this is a close calculation, even if the data upon which it is based be deemed admissible in the form I have given them; and the frequency and energy with which the upheaving force acts, coupled with the fact that when a mudlump rises in the channel, so far from suffering denudation to the extent required for the breaking through of the mud, it more generally causes a silting up of the channel: seems to me to indicate that a stronger force, less delicately balanced than the equilibrium of the bar, is "at the bottom" of the whole phenomenon.

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* Humphreys and Abbot's Rept., p. 446.

This force, I think, is to be sought in the constantly increasing weight of the alluvial area above the mouths, which, itself possessing a series of mudlump vents at one time, must yet be resting in a great measure upon the still unexhausted mud stratum; as is proven by the existence of active lumps in the marshes, even though the increased resistance of superincumbent deposit as well as matted vegetation must render their occurrence there a rarity. There must still be a communication of liquid pressure between the older and newer portions of the modern delta; and this point is especially strengthened by the fact that a high stage of water in the river, which does not sensibly affect the depth on the bars, yet exerts a decided influence on mudlump activity. The river not only overflows the marshes, but loads them with additional sediment; and doubtless the increased hydrostatic pressure stops many a vent of gas, mud or water, which ordinarily discharges into the river's bed.*

Morgan's Lump, in the marsh of Southwest Pass, and Marindin's Lump on Passe à l'Outre, are now known to have been in undiminished activity for twenty-five years at least. Since that time the bars have moved gulfward a mile and a half; and one would think that, if the activity of the cones depended upon them alone, a notable difference ought to have been observed. But if the main force is a *vis à tergo*, while the bar serves mainly to prevent the escape of the mud to seaward, there is good cause for the secular persistence of vents that have escaped mechanical obstruction.

How far above the present mouths the head of pressure may extend, I do not pretend to conjecture. The borings at New Orleans seem to indicate that the mud stratum originally existed there also, but it would be extravagant to suppose that such pressure as that exerted in the gas wells of that city, could now be felt a hundred miles below. Yet it seems not at all unlikely, that the weight which steadily forces up the liquid mud to the top of Morgan's Lump, seven miles above the mouth, may, in part, be furnished by the enormous mass of vegetation which annually develops in the marshes, willow battures, and perhaps even cypress swamps above. Nor is the effect of gaseous pressure resulting from the constantly progressing decay of organic matter to be overlooked, although I doubt that this cause plays, ordinarily, anything more than a very subordinate part.

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* I give on the plate (page 358) an ideal section, illustrating this explanation of the "origin of mudlumps."

Future observations, systematically carried out, will doubtless solve a good many of the questions here mooted; and though they may not lead to the suggestion of any means whereby the "evil geniuses of the Passes" may at present be conjured, a more precise knowledge of data, as well as of the statics and dynamics of *mud*, may enable us to predict at what point of advance of the mouths into the deeper water of the Gulf, their formation must cease. The Southwest Pass appears to be nearest that consummation devoutly to be wished; and were the closing of the other outlets practicable, the advance of the Southwest bar might become so rapid, as to let the youngest of the living generation witness a diminution of mudlump upheaval. Ultimately, the mouth might thus become similar to those of the Orinoco and Amazon; but until then, ceaseless activity of the river in the formation of bars and mudlumps must, in the interest of navigation and commerce, be met by an equally ceaseless and diligent effort for their removal from the channel. For while a concentration of the river current might possibly be made to maintain the needful depth upon the bars, its utmost erosive energy will be powerless against the tough, inert masses of the mudlumps.

ART. LXIII.—*Observations on the Structure and habitat of the Stephanurus dentatus* Diesing, *or Sclerostoma pinguicola* Verrill; by WM. B. FLETCHER, M.D.

THIS parasite, well known throughout the west as the "kidney worm," was first discovered, as I am informed, by Nattser, at Barra De Rio Negro in the white China hog. Although so common and injurious in this country, it had not received attention until 1870, when Prof. Verrill, from imperfect specimens, gave it a name and suggested its importance to the agricultural world.*

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* Subsequent to the publication of my descriptions of this species in the Report of the Connecticut Board of Agriculture for 1870, and this Journal, vol. 1, p. 223, I found a notice, apparently of the same worm, by Dr. J. C. White, in the Proceedings of the Boston Society of Natural History, vol. vi, p. 428, Dec., 1858. Dr. White referred it doubtfully to *Stephanurus dentatus* Dies. or *Sclerostomum dentatum* Rud. (an identification that is still quite doubtful) and gave an account of its occurrence in cysts in the leaf-lard of a hog, a male and female together.

Dr. Cobbold, from information received through Dr. Fletcher, has recently published a short account of this parasite, under the same name, in the British Medical Journal (see also Nature, Jan. 26, 1871).

During the past winter I have known of several additional cases in New England. In one instance I obtained a number of fine specimens from a portion of the leaf-lard, taken from a hog raised in Litchfield county, in this state. They occupied large irregular cavities or cysts, sometimes over an inch long and partially filled with dark, disagreeable pus, in which there were numerous eggs. The cysts usually contained a male and female worm, but some contained three and others only one.—A. E. V.

This worm was brought to me in 1866, by a farmer whose hogs were dying of cholera. He had removed the lungs of several, and also cut out fragments of the liver, all of which were spotted over with little cysts containing the worms; in the bronchial tubes down to the minutest branches, they were found in abundance and in situations where no one could have placed them.

With these specimens my conclusion was that they were the *Filaria bronchialis* of Owen, or *Strongylus bronchialis* of Cobbold, and not having at this time made microscopic examination of our well known kidney-worm, the relationship between them did not occur to me at that time.

In November, 1870, while demonstrating the portal circulation in the liver of a pig, full grown, I observed a worm which measured an inch and a half in length, and in all respects resembled the kidney worm, and also reminded me of the worms I had examined five years before. Upon further dissection of the liver I found the worms not only free in the portal veins, but in cysts in various portions of the organ; also some were found in freshly cut holes, directly across the hepatic lobules. The gall-bladder was distended with a dirty, yellowish fluid, the consistency of soft boiled eggs, and although no worms were found, yet the ova were abundant, as they also were in the fluid of the cysts.

Being convinced that the worm formerly examined in the lungs was the same as the worm now found in this new locality, and finding it oviparous, I gave up my opinion as to its being a *Filaria bronchialis.*

From the date of this discovery, I frequented the slaughter houses and pork-packing establishments, and found the worm in most instances in the pelvis of the kidney, or in cysts in the fat around them. Four times I have found the worm in the bronchial tubes, twice in the hepatic vein and in the right side of the heart; also in cysts throughout the fatty parts of the animal.

Frequently, when no worms were discovered, the eggs were abundant in the thick mucous-looking fluid in the pelvis of the kidney. This fluid contained, besides eggs, desquamated renal tubules, or casts and oily granules.

In no instance have I found worms in an immature state, which shows that the eggs, in all probability, go through some other beast before they enter the swine, to become sexually mature.*

The symptoms in hogs, which are referred to the "kidney worm," are due to a paralysis of motion in the hind legs; the

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*** It is quite as probable that they may hatch in water, and thus ent-r the hog's stomach with its drink.—V.**

hog drags the hind quarters along the ground from place to place in search of his food, although it is by no means proven that the worm is the real cause, unless we be able to demonstrate its existence in some cerebro-spinal center, or some point more likely to destroy the reflex power in the cord itself.

Structure.—The head and oral cavity are alike in male and female. The oral cavity is rather oval than round, and is surrounded by a hexagonal frame, each corner having a papilla and hooklet, while each side is armed with six serrate teeth.

Looking into the oral cavity, it is funnel-shaped, having three openings at the back, one of which connects directly with the œsophagus, while the others appear to connect with the water vessels.

The intestine is long and contains some pigment granules, arranged in dendritic forms, throughout its length; the whole is thrown into convolutions, and gives an almost black appearance to the worm, except when the white oviducts distended with eggs, or the seminial vessels of the male are folded over the intestine, when it has a white, mottled appearance.

The caudal extremity of the female is spindle-shaped, but has two little bursæ higher up. In the male it is formed by three-lobed bursæ, above which are two well developed flexible spiula.

ART. LXIV.—*On certain Forms of the Electrical Discharge in Air;* by Prof. ARTHUR W. WRIGHT, Williams College.

IN a paper published in this Journal, May, 1870, the writer described a peculiar form of discharge between the poles of the Holtz electrical machine, worked at high tension, and without condensers. A non-luminous discharge was observed to take place over a considerable interval, with the production of a jet or brush upon the negative, and a glow upon the positive ball, and the formation in this glow of shadow-like images of objects placed between the poles. It was shown also that the discharge passed over lines having a definite form, and that they were curved so as to form arcs issuing normally from the surfaces of the poles.*

When the condensers are employed the dark discharge also occurs under certain circumstances, and exercises an important influence on the nature of the phenomena observed. If the poles of the machine are gradually separated, a point is soon reached, at which the bright sparks appear very irregularly or cease altogether, the polar interval being then usually some four or five inches, but varying considerably with the circumstances of the experiment. Examination readily shows that at such times a dark discharge is taking place, and shadows may be produced in the same manner as when the condensers are not used, but less readily, and with less distinctness. The discharge now becomes very variable in character, passing from the ordinary bright spark to the non-luminous form already described, and all intermediate grades may be observed, according to the energy of the jet, or the tension of the poles.

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* Faraday described the form of discharge which produces the glow, and called it the *dark discharge.* He also held that the inductive action between two bodies took place along curved lines, as was indicated by certain forms of the luminous discharge. (Exper. Res., 1444; 1544, et seq.; 1215, et seq.). The occurrence of the shadows, however, enables us to trace these lines of action very accurately, especially when the glow is made to take the form of a narrow ring, as is described in the paper referred to above.

Often an incomplete spark passes, consisting of two portions issuing simultaneously from the poles, the middle portion being quite dark. The two ends, in this case, are usually characterized by many branches, which are more numerous and longer in the part next the positive pole, and the whole exhibits a reddish color, and a feeble degree of illuminating power, as compared with the perfect spark, while the detonation of the discharge is correspondingly enfeebled. This is the case distinguished by Riess as the "weak spark" (*schwache Funke*),* and it is characterized by him as a distinct form of the discharge, due to a diminution of the tension of the electricity.

That under particular circumstances, or with a special arrangement of the machine, such as to give electricity of lower tension, the weak sparks are produced more frequently, is true, but the fact that they are often formed when the potential of the machine is very high, shows that they are not dependent on that alone, but rather upon the tension at the poles, at the instant of discharge. In these cases, the poles being separated but a few inches, a rapid jet-discharge takes place, with the production of the phosphorescent glow above described. Now when this occurs, a silent discharge is going on through the air, and this may be so energetic as completely to prevent the formation of the ordinary spark, and to lower the tension at the poles very considerably. A variation in the rapidity with which the machine is worked, or the prevention or weakening of the jet by any means, may then raise the tension of the poles sufficiently to determine the passage of the weak sparks, or even of the ordinary bright ones.

It may be supposed that, at the distance in question, the mutual inductive influence of the two poles is just sufficient to cause a local increase of tension there, to such a degree as to enable the negative electricity to overcome the resistance of the air, thus setting up a sort of current between the poles. And it is noticeable that after such a current is once established the poles may often be gradually separated to a much greater distance without interrupting it, though if, after this greater separation, the spark passes, or the poles are touched with a conductor, the current is not readily re-established without approaching them to each other again. The analogy of this circumstance, as well as of the curved form of the lines which the current often exhibits, with similar phenomena of the voltaic arc, is obvious.

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* Pogg. Ann., Bd. cxxxvii, p. 451; Bd. cxxxix, p. 508.

Riess has remarked (loc. cit.) that the weak spark may be regarded as the germ of the complete and bright sparks. We may go further, however, and say that the brush-discharge is the germ of both the others, and indeed of most of the luminous forms of discharge. When an elongated conductor, connected with the machine and highly charged, is insulated, and so far removed from any other conducting body that the attractive influence of the latter is null, or may regarded as such, the tension quickly rises to a maximum at the extremities, and, if these terminate in blunt points or small balls, finally overcomes the atmospheric resistance, and a discharge occurs in the form of a brush, or rather in that of a tree, the stem of which is toward the charged body. The ramified form of the discharge is evidently due both to the tension of the electricity, and to the small electrical capacity of the air. The portion of the air in contact with the pole becomes highly charged and is then repelled, and a stream of such particles will follow in rapid succession. Each of these particles communicates a portion of its charge to others which it touches, and so is in a condition to receive more electricity from the charged body. Thus is established, not merely a convective action in the particles of air, but also a current of electricity passing along the stream of particles. The stream or thread of air is heated by the passage of the electricity, and all the more as its resistance is very great. With the rise in the temperature, however, its conducting power is increased, and it thus not only conveys a larger quantity of electricity, but becomes more highly charged, until finally, acting itself as a highly charged body, it gives rise to other streams forming branches or lateral discharges, which in turn give rise to other ramifications, thus producing the familiar arborescent forms of the discharge.

When two conductors oppositely charged with electricity are brought so near one another that inductive action becomes sufficiently intense, we may have either the silent and non-luminous discharge, or if the quantity of electrity is too great to find its equilibrium in this manner, the brush-discharge taking place from both poles simultaneously, and greatly intensified by their mutual action. The branches become longer, more distinct, and more highly luminous, and when the distance between the poles is so small that the branches are separated by a comparatively small interval, we may have the weak spark. Finally, when the quantity of the electricity is increased, or the tension at the poles becomes greater, or the distance between them is lessened, the branches of the primary discharge may become so much extended as to meet, or at least to come into close proximity. Now it is well known that when a body has been traversed by or charged with electricity either positive or negative, it becomes a better conductor for electricity of the opposite nature. In case then any branch from one side, say the positive, should meet one from the other side, namely, the negative, each would form for the electricity of the other a better path than the surrounding air, both from this cause, and from the fact that it has a higher temperature. The main body of the charge then would follow the path thus opened, and the thread of air which it traverses being thereby very highly heated would exhibit the intense brightness of the ordinary spark. The fact that the discharge passes along the irregular branches of the brush then sufficiently explains the crinkled and variously contorted forms of the bright spark, when the tension is very great. With a machine affording electricity of high tension, the branches accompanying the bright sparks, when the latter have a length of some inches, may be readily seen even in the daylight. The longer and more numerous proceed from toward the positive side, but those directed from the negative are frequently visible. They are much shorter and less distinct than the former. Sometimes short and faint branches issue from different points of the negative pole itself, several appearing at once, simultaneously with the spark.

From the fact that the air in the path of the spark is rendered a better conductor by the intense heat, it might be expected that where a rapid succession of discharges passes, the successive sparks would follow the same path, and therefore have the same form, as the air-thread would not instantly communicate its heat to the air surrounding it. The researches of Feddersen and of Prof. Rood have shown that in the discharge of the Leyden jar through a short interval, the spark is intermittent in its character, consisting in fact of several discharges in rapid succession. As the bright path appears to the eye single and sharply defined, it is very probable that their paths are all identical, namely that of the first act of the discharge. With the Holtz machine also, used without condensers, the discharges may be made so rapid when the poles are but an inch or less apart, as to appear continuous, and to give a tone whose pitch can be definitely recognized. In such a case the lines of the discharge seem to oscillate rapidly in a plane which has different inclinations as the thread of air is moved in one direction or another, either by currents in the surrounding air, or, as apparently happens, by the attraction of the charged parts of the machine. When no disturbing cause affects it, the plane will tend to take a vertical position, from the diminished density of the air-thread which is heated by the discharge. In any case, as it moves from its first position, and the repeated discharges pass through it, it occupies positions successively farther from the original line, until from its increased length the resistance becomes too great, and the discharge occurs again near the initial position, and so on. Owing to the persistance of the impression in the eye several lines are seen at once, apparently simultaneous, but that they are not so may be readily made evident by suddenly moving the eye while looking at them, or by viewing them in a mirror which is quickly turned about, when the intervals between them are seen to be drawn out and enlarged, whereas these would be unchanged if the discharges occurred at the same instant, or were continuous.

The effect becomes much more striking when the poles are so shaped as to increase the vertical length of the space between them. For this purpose an experiment was made by attaching to the inner extremity of each electrode a brass tube about six inches in length and half an inch in diameter, the upper end being hemispherical, and the tubes fixed in a vertical position. When the electrodes were pushed in so that the tubes were from one-quarter to one-half of an inch apart, and the latter were brought as nearly as possible to parallelism, sparks passed in quick succession between them, and now and then appeared to rise rapidly from the lower portion of the interval toward the top. When the condensers were employed, and the tubes were brought nearer together, the same effect was observed, but indistinctly and less frequently, as the discharges succeeded one another too slowly to make it readily apparent.

A phenomenon of the same kind is often presented in lightning flashes. It is no uncommon thing during a violent thunder-storm, to see two, three, or even more discharges of lightning follow the same path in quick succession, the interval between them being but the fraction of a second, yet sufficient to be distinctly perceptible. In this case the mass of air heated by the discharge is comparatively great, so that a considerable time is required for it to become cooled by the enveloping air, and it therefore retains its superior conductivity long enough to determine a repetition of the discharge through it.

The formation of the electrical shadow discussed in my former paper, as has been suggested by Mr. C. F. Varley,* who has more recently obtained results similar to those there described, appears to afford a satisfactory explanation of a singular and very interesting phenomenon which has occasionally been observed in the case of objects struck by lightning, especially of persons killed by it. A number of instances are on record where the person struck was found to have impressed upon some portion of the body a delineation of some thing near him at the time of the stroke, and a similar effect has been noticed also in the case of inanimate objects. Dr. Franklin mentions an instance in which an exact representation of a tree was imprinted upon the breast of a man who was standing near it when struck by lightning. A number of similar and very remarkable cases are cited in a paper presented to the Royal Society of England, by Mr. Andrés Poey, director of the observatory at Havana.*

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* *Nature*, vol. iii, p. 238, in report of Proc. Roy. Soc. for Jan. 12, 1871.

Mr. Varley also mentions cases reported by sea-captains, of images of certain brass numbers attached to the rigging of a ship being printed by the lightning upon the body of persons killed by it, and supposes the brass numbers to have acted as a negative pole in respect to the person struck. But it is unnecessary to suppose that the discharge in such cases always proceeds from the object delineated, and many of the instances recorded forbid such a supposition. The experiments in the production of the electrical shadows show that it is merely necessary that the object should interrupt the lines of action of the electricity, and that it may be at a considerable distance from the electrified cloud, the chief and indispensable condition being that the latter should be negatively electrified. We should then have the body exposed to the lightning positively electrified by induction, and, as the tension became sufficient, the dark discharge accompanied by the glow would take place, followed by the lightning-stroke. If then any object should be in the path of the discharge, its image would be formed in the glow, and this might, in rare cases like those recorded, be sufficiently intense to leave a permanently visible impression. The fact that the image in many cases is very much reduced in size, shows indeed that the cloud, or other body serving as the negative pole, is much more distant from the object represented than is the body struck, for in the experiments described in my former paper, it was found that the image of the paper grating grew much smaller as it approached the positive pole, and this effect would be likely to be still more marked where the negative body had a very extended surface, as would be the case were it a cloud.

In some experiments recently made, the negative pole of the machine was covered with several folds of woolen flannel which prevented the formation of a jet. Instead of this, several square inches of the cloth were covered with a bright glow, somewhat resembling that on the positive ball, but, unlike that, seemingly made up of innumerable minute points or patches of light, having a peculiar swarming motion, like that described by Neef in his researches upon the negative discharge as seen under the microscope. When the paper grating was placed between the poles, the image on the positive was not readily obtained with distinctness, but was generally much smaller than when the negative pole was not thus covered.

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* See an abstract of this paper in the Ann. Sci. Discovery, 1858, p. 226.

A similar effect, but much more brilliant, was produced when, the poles being separated nine or ten inches, the hand was placed upon the negative, and the arm was approached to the positive pole. The woolen sleeve exhibited a bright glow covering a large area, and appearing like a strongly phosphorescent powder sifted profusely upon it. When this was approached so near that the interval was only an inch and one half or an inch, the positive glow became much more intense, and took a delicate purplish tinge, and the whole space between the two was filled with a very faint auroral light, which appeared, unlike other forms of the discharge, to be perfectly continuous and steady. The dark discharge under these circumstances was evidently so much intensified as to become luminous and visible.

Williamstown, Mass., April 22, 1871.

ART. LXV.—*Brief Contributions to Zoölogy from the Museum of Yale College.* No. XIV.—*Descriptions of new and imperfectly known Ascidians from New England;* by A. E. VERRILL.

[Continued from page 294.]

Family, DIDEMNIDÆ.

In this family we include, together with the typical genera, *Leptoclinum* and its allies, which have been separated as a distinct family (*Leptoclinidæ*) by Prof. Gill.* There appears to be no definite ground for such a distinction. The genera *Didemnum* and *Leptoclinum* are very closely allied, and scarcely distinguishable so far as the structure of the individual zoöids is concerned, the difference being chiefly in the mode of aggregation. Such differences are generally of too little importance among compound animals to form the basis of family distinctions, unless accompanied by important differences in the individuals themselves.

* Arrangement of the Families of Mollusks, p. 23, 1871.

Lissoclinum, gen. nov.

Allied to *Leptoclinum*. The colonies form more or less broad, thin, encrusting masses or sheets, soft and somewhat gelatinous in texture, without calcareous corpuscles. The zoöids are arranged in more or less irregular, scattered systems, consisting of many individuals placed along cloacal ducts, which are connected with common external orifices. Branchial region, or "thorax," equal to or larger than the abdominal. Branchial orifice with six papillæ. Anal orifice lateral or subterminal, prominent. Abdomen separated from thorax by a short peduncle. Stomach with longitudinal glandular ridges. Ovary sublateral, when filled with eggs projecting backward beyond the abdominal viscera. Eggs large.

This genus differs from *Didemum** and *Eucœlium* in having common cloacal ducts and orifices, as well as in the form and position of the abdomen and ovary. From *Leptoclinum* it differs in the soft gelatinous texture and in the form and structure of the zoöids.

Besides the two following species, this genus appears to include *L. gelatinosum* and *L. Listerianum*, both of which were referred to *Leptoclinum* by Milne Edwards.

Lissoclinum aureum, sp. nov. Figure 26.

Colonies encrusting, forming nearly flat masses, about ·15 to ·20 of an inch thick, and up to an inch or more in diameter. Texture soft and gelatinous, semi-transparent. Systems irregular, consisting of many individuals arranged along the elongated, common cloacal ducts. Branchial orifice with six rather elongated and slender papillæ. Branchial sac broad and laterally extended, with the transverse vessels quite distinct, and the longitudinal ones less so. The œsophagus is short; stomach more or less oval and elongated, with well-marked longitudinal ridges or glands; intestine large, prolonged toward the anal orifice. The anal tube is nearly terminal, conical, and more or less prominent. Ovary lateral, when full of eggs projecting backward beyond the end of the abdomen. Color of the common mass light yellow; zoöids bright orange.

26

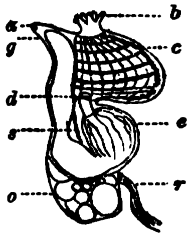

Figure 26, *Lissoclinum aureum* V.—One of the zoöids, enlarged 10 diameters; *a*, anal orifice; *b*, branchial orifice; *c*, branchial sac; *d*, œsophagus; *e*, stomach; *g*, end of intestine; *o*, ovary distended with eggs of various sizes; *r*, "marginal tube" or pedicle of a bud; *s*, spermatic duct. (From a camera-lucida drawing by the author).

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* The genus, *Didemum*, as established by Savigny and adopted by Milne Edwards, includes two distinct groups: the first having calcareous corpuscles in its integument; the second soft and gelatinous throughout. The latter may be called *Lioclinum*. It includes *L. viscosum* (Sav.) and *L. gelatinosum* (Edw.).

The zoöids, as preserved in glycerine, are ·10 to ·13 of an inch long; breadth, across branchial sac, ·05 to ·07; across abdomen, ·05 to ·06; length of thorax ·04 to ·07; of peduncle ·005 to ·010; of abdomen ·045 to ·055.

Eastport Harbor, 12 to 20 fathoms,—Expedition of 1870.

The cloacal ducts of a specimen taken in August, were found to be filled with chains of eggs containing the tadpole-shaped embryos in an advanced stage of development. No eggs or embryos were observed in the atrium of the numerous zoöids examined.

Lissoclinum tenerum, sp. nov.

Colonies encrusting shells, ascidians, etc., forming thin, soft, gelatinous crusts, which are translucent, and filled with numerous, very small zoöids, which are nearly uniformly distributed. Cloacal openings small, round, numerously scattered over the surface. Zoöids have the branchial region more elongated and narrower than in the preceding species, with a somewhat larger peduncle between it and the abdomen, and with the latter, exclusive of the distended ovaries, smaller than the branchial region. Stomach elongated, longitudinally ribbed. Branchial tube elongated, with six short papillæ; anal short, broad, lateral, below the middle of the branchial sac, slightly six-lobed.

Color not observed in life; in alcohol transparent whitish, with yellowish white zoöids.

The colonies are up to two inches in diameter and ·10 to ·12 thick; zoöids about ·07 long; the thorax ·032, by ·02 wide; the abdomen ·025 long, by ·015 in diameter, exclusive of the distended ovaries, which in some cases are as large as the entire body.

Eastport, Me., 10 to 40 fathoms, shelly bottom,—Exp. 1870; Banks of Newfoundland,—T. M. Coffin.

This species may be easily distinguished from the preceding by the very small zoöids and paler color. The zoöids are very different in form, owing to the lateral position of the anal orifice. The stomach is remarkably elongated and slender in young individuals, projecting into a posterior prolongation of the abdomen. The eggs are few and relatively very large. Many of them appear to become detached by rupturing the membranes of the ovary, and escaping into the gelatinous common tissue, develop there.

The development of such eggs* is *direct, without passing through a tadpole-shaped larval state.* Scattered through the common gelatinous mass, young ones may be found in all stages of development. The branchial and anal tubes are widely separated in the young, and the stomach projects backward beyond the body.

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* With the alcoholic specimens it is not possible to trace completely the early stages of this development, or to be perfectly certain that these egg-like bodies are genuine eggs, although some of them appear to contain, at first, a germinal vesicle.

Leptoclinum albidum, sp. nov.

Colonies encrusting stones, dead shells, ascidians, etc., forming broad, thin, irregular, coriaceous crusts, with an uneven surface, filled with minute, white, spherical, calcareous grains or corpuscles, which, under the microscope, have the surface covered with projecting points. Surface of the crusts covered with small, irregular, scattered prominences, in which the branchial orifices are situated. Cloacal orifices few and distantly scattered. Systems irregular, the zoöids scattered, but often arranged in rather indistinct concentric circles around the cloacal openings.

Color white, the zoöids light yellowish.

The colonies often become 1 to 2 inches across, sometimes 2 inches or more long, and only ·25 or less wide; thickness seldom more than ·10, commonly about ·05; zoöids ·02 to ·03 long; diameter ·01 to ·012 of an inch.

Eastport, Me., low water on under side of rocks, to 100 fathoms on stony and shelly bottoms, common.—Expeditions of 1863, '64, '68, '70; Grand Menan, 10 to 15 fathoms,—Exp. 1870; Labrador,—A. S. Packard; Mingan Islands, Lab.—A. E. Verrill; Banks of Newfoundland, — T. M. Coffin; Thimble Islands (near New Haven), Conn., 6 fathoms, on rocky bottom,—A. E. Verrill.

Leptoclinum luteolum, sp. nov.

This species forms thin, coriaceous crusts, like the preceding, and filled in the same way with similar spherical corpuscles. The branchial orifices open at the summits of low verrucæ. The cloacal orifices are small, with four to six lobes, and distantly scattered. Color deep salmon, or somewhat rosy.

The crusts are of all sizes up to 2 inches or more in diameter, and are usually somewhat thicker than in the preceding species, with larger and darker colored zoöids.

Eastport, Me., and Grand Menan, with the preceding species,—Expeditions of 1861, '63, '64, '68, '70,

Under the name of "*Didemnium roseum* Sars" Dr. Packard* probably included both this and the preceding species. Mr. Binney, in the second edition of Gould's Invert. of Mass., has merely copied from Dr. Packard's work.

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* Memoirs of the Boston Society of Natural History, vol. i, p. 276, 1867.

ART. LXVI.—*Notice of some new Fossil Reptiles from the Cretaceous and Tertiary Formations;* by O. C. MARSH, Professor of Paleontology in Yale College.

THE remains briefly described in the present preliminary notice were collected by the Yale College party during their explorations last summer in the Rocky Mountain region. The specimens from the Cretaceous formation are of great interest, as they further illustrate the remarkable development in this country, both in numbers and distinct forms, of the Mosasauroid Reptiles, which appear to have been comparatively rare in other parts of the world. Fortunately, moreover, some of these remains serve to clear up several obscure points in the structure of these reptiles, and prove conclusively that they had a well developed pelvic arch and posterior limbs; although up to the present time no satisfactory indication of this had been discovered, and the eminent paleontologists who have recently made these animals an especial study consider them probably destitute of these extremities. The remains found in the Tertiary deposits are also of importance, since they show that types of reptilian life, almost unknown hitherto from that formation in the West, were, in one of the ancient lake-basins at least, abundantly represented there during that period.

CRETACEOUS REPTILES.

*Edestosaurus** *dispar*, gen. et sp. nov.

This genus, which so far as now known includes but two species of small Mosasauroids, is especially distinguished from *Clidastes*, its nearest ally, by the insertion of the pterygoid teeth, which are pleurodont in the anterior half of the series, and in the posterior portion have the outer dental margin protected by a low parapet of bone. From *Platecarpus*, the genus is widely separated by the zygosphene articulation of the vertebræ. The pelvic arch and posterior limbs were well developed, but there was apparently no sacrum.

The present species is mainly established on the more important parts of a skeleton, including the greater portion of the skull, both quadrates, about seventy vertebræ, parts of the scapular and pelvic arches, and fragments of the limbs. The remains are in an excellent state of preservation; and indicate a Mosasauroid reptile, apparently about thirty feet in length, or near the size of *Clidastes iguanavus* Cope.

The vertebræ possess the complete zygosphene articulation. In the cervicals and anterior dorsals, the cup and ball are somewhat inclined; in the posterior dorsals and lumbars, less so;

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* Ἐδεστής, devourer, and Σαῦρος, lizard.

and in the anterior caudals they are nearly, but not quite, vertical. The articular faces in the cervicals are a broad transverse oval, faintly emarginated above for the neural canal. In the dorsals and lumbars the cup continues transverse, and the emargination is deeper, but in the anterior caudals the outline becomes a vertical oval. The posterior lumbars have the faces hexagonal, with both the upper and lower borders excavated, the latter due to the concave inferior surface of the centrum in this part of the series. The rim of the articular ball in all the vertebræ preserved is surrounded by a distinct, but not deep, double groove. The chevron bones are coössified with the centrum.

The quadrate has the same general form as in *Clidastes propython*, but the external angle is situated further back, and has a notch in its posterior margin directly above the meatal pit. The postero-superior process is shorter, with a compressed free end. The teeth are curved, and somewhat compressed. The enamel is smooth, and shows faint indications of broad facets on the basal half. There appear to have been thirteen mandibular teeth, with alveolæ for two more. The splenial extends forward to the base of the seventh tooth from the front. The pterygoid bones were separated, except perhaps at their anterior inner margin. There were at least fifteen pterygoid teeth. The crowns are smooth, with distinct posterior cutting edges.

There is a remarkable difference in size between the cervical vertebræ and those of the lumbar region, where the centra reach their maximum. Although the series is here apparently complete, there are no indications of a sacrum. The discovery of the nearly entire pelvic arch with these vertebræ, and the preservation, also, of the corresponding anterior arch, throws much new light on the nature of the limbs in this group of reptiles. These specimens clearly indicate that the bones forming this portion of the skeleton in the Mosasauroids have not unfrequently been incorrectly assigned, and that two at least of the allied genera, viz: *Clidastes* and *Liodon*, also possessed effective posterior limbs. Several series of specimens illustrating this are in the Museum of Yale College, and will soon be described by the writer.

In this species the scapula and coracoid bones are similar to those of *Mosasaurus*. Both are short and flat; each thickened at one extremity, which it contributes to form the glenoid cavity, and at the other, thin and expanded. The coracoid is perforated by a foramen not far from its anterior margin. The pelvic arch resembles that of *Ichthyosaurus*, and, as in that genus, is considerably smaller than the anterior arch. The acetabulum is cup-shaped, and is not unlike that in *Trionyx*. It is formed by the union of the ilium, pubis, and ischium, the first furnishing the largest, and the last the smallest portion of the articular surface. The body of the ilium is remarkably slender, and the proximal end was probably attached to a vertebra merely by cartilage. The distal extremity is much expanded, subrhombic in outline, and has three nearly equal facets on its articular surface, that forming part of the acetabulum being the largest. The adjoining proximal end of the pubis is more compressed than that of the ilium, and has three corresponding articular facets, the acetabular being nearly flat, and the others concave. The portion below is flattened, and has a foramen near its anterior margin. The proximal end of the ischium is also trihedral, and somewhat smaller than that of the pubis. The articular surfaces of all these bones were thickly capped with cartilage. The few phalanges found with these remains are rod-like, depressed, and much constricted medially. The ends are transverse, and have been covered with cartilage. They indicate that the limbs were paddles, not unlike those of *Plesiosaurus*, but more slender.

Measurements.

Length of axis,	26·	lines.
Length of axis, with odontoid process,	32·	“
Width between diapophyses,	26·8	“
Width of articular ball,	11·25	“
Depth of articular ball,	9·25	“
Length from edge of cup to end of ball in eleventh vertebra,	25·	“
Width of ball,	14·	“
Depth of ball,	12·	“
Length of first caudal on inferior surface,	16·	“
Width of articular cup,	14·5	“
Depth of cup,	15·	“
Length of quadrate,	30·75	“
Transverse extent of distal end,	18·75	“
Length of pterygoid bearing the five anterior teeth,	33·5	“
Length of portion with the five posterior teeth,	23·	“
Antero-posterior diameter of distal end of ilium,	14·5	“
Transverse diameter,	11·30	“
Diameter of shaft,	4·75	“
Greatest diameter of proximal end of pubis,	16·30	“
Transverse diameter,	10·	“
Greatest diameter of proximal end of ischium,	14·	“
Transverse diameter,	9·	“

This species is readily distinguished from *Clidastes iguanavus*, by the less depressed and more constricted centrum in the anterior dorsals. It differs essentially also from *Clidastes cineriarum* Cope, in having transverse articular faces in the vertebræ of the dorsal and lumbar region. The specimens representing this species were discovered, in November last, by Mr. H. B. Sargent and the writer, in the gray Cretaceous shale, on the North Fork of the Smoky River, in Kansas.

Edestosaurus velox, sp. nov.

This species was about two thirds the size of the preceding one, and very nearly allied to it. It is represented at present by a number of specimens found together, including the greater part of the skull, with the quadrates, and several vertebræ, which, however, are too much crushed to give reliable measurements. Another series of specimens, consisting mainly of anterior dorsal vertebræ, well preserved, was found near the same locality and appears specifically identical. They are therefore included in the description of the species, and furnish the vertebral characters of the dorsal region, where the first series is deficient.

The muzzle in this species is obtusely pointed. The premaxillary is narrow and simple, and unites with the maxillaries, anteriorly at least, by suture, differing in this respect from the known species of *Clidastes*. There are four premaxillary teeth, smooth and subcompressed, like those of the maxillaries. The pterygoid bones are very similar to those of the preceding species. The quadrate, also, has the same general form, but presents several marked differences. The great ala is less curved vertically, and is concave transversely on both surfaces. The alar process has its articular surface very narrow in its extension over the great ala, while in *E. dispar*, it is broad and abruptly terminated. There is no notch in the posterior margin of the external angle. On the ridge below this angle, and nearly opposite the meatal pit, there is a prominent rugosity, which is rudimentary or wanting in the larger species. In the latter, moreover, the posterior margin of the hook is reflected for some distance, producing a broad articular face. In the present species, this surface is only represented by a narrow tongue, projecting toward the meatal pit.

In the cervical and dorsal vertebræ, the articular faces are transverse, and in the latter, distinctly cordate, the superior emargination being deeper than in the preceding species. In the anterior dorsal region, the vertebræ have a more transverse cup and ball, which are also apparently more inclined from a vertical.

Measurements.

Length of anterior dorsal vertebra, from edge of cup to end of ball,	22·	lines.
Width of ball,	12·	"
Depth of ball,	10·	"
Length of pterygoid bearing five anterior teeth,	25·5	"
Length of pterygoid with five posterior teeth,	19·	"
Length of quadrate,	27·75	"
Transverse diameter of lower end,	14·	"

This species was apparently about the size of *Clidastes intermedius* Leidy, but may easily be distinguished from it by its smooth teeth, and the more nearly vertical articular faces of the vertebræ. The present specimens were found by the writer, in the gray shale, near the North Fork of the Smoky River, in Western Kansas.

Clidastes Wymani, sp. nov.

The remains on which this species is based consist of a series of cervical and anterior dorsal vertebræ, with portions of the skull and quadrates of the same individual, and portions of another skeleton, including a nearly or quite complete vertebral series from the posterior lumbars to the extremity of the tail. The two suites of specimens correspond so closely in size and proportions, as well as in special characters, that they may with comparative safety be referred to the same species.

The specimens indicate a small reptile, very near *Clidastes propython* in size, but differing from that species in several important particulars. One of the most noticeable of these is the form of the muzzle, which in the present example has a short and obtuse extremity, not unlike that of *Liodon proriger* Cope. The basioccipital has the condyle deep vertically, and only a shallow groove on its upper surface for the neural canal. The quadrate has the postero-superior process free at its lower extremity. Just below this, there is a prominent rugose knob, with a deep pit under it, entering from the external border.

In the cervical vertebræ, the outline of the articular faces is transverse cordate, the ball of the axis showing a marked difference in this respect from that of *Clidastes propython*, where it is subpentagonal. The centra of the anterior dorsals are elongate, and much constricted behind the diapophyses. The cup here becomes broader, and the emargination deeper. In the anterior caudals, the articular faces are a broad vertical oval. The vertebræ in this region have deeply concave sides. In the twenty-fifth caudal, or vertebra with chevrons where the last rudiment of the diapophysis has disappeared, the transverse and vertical diameter of the cup, and the length of the centrum are very nearly equal. In the median caudals, the centra become compressed, the cup is very shallow, and the neural spines and chevrons are directed backward. The posterior caudals are much compressed, with the cup very deep, the neural spine still inclined, but the chevrons are nearly perpendicular. The entire caudal series, excepting those at the very extremity, have coössified chevron bones. There are eighty-one caudal vertebræ preserved, the last fifty being continuous. The terminal ones are less than one-twelfth of an inch in transverse diameter! This series would imply that there were considerably more than two hundred vetebræ in the entire column, and hence indicates for these reptiles a much more attenuated, serpent-like form than has hitherto been supposed. The present species was probably about eighteen feet in length.

Measurements.

Length of axis, with odontoid process,	19·	lines.
Width between diapophyses,	17·	"
Width of ball,	8·	"
Depth of ball,	7·	"
Depth of centrum, with attached hypapophysis,	10·3	"
Length of sixth cervical, without ball,	13·	"
Length of neural arch,	10·	"
Width in narrowest point,	6·40	"
Width of cup,	9·	"
Distance from end of muzzle to center of first tooth,	5·5	"
Length of caudal on which diapophyses first disappear,	9·1	"
Width of cup,	9·	"
Depth of cup,	9·	"
Length of caudal, apparently next to last,	1·40	"
Transverse diameter of same,	·95	"

This species is named in honor of Professor Jeffries Wyman, of Harvard University. The remains at present representing it are from the gray Cretaceous shale of Western Kansas. The first series of specimens here described was discovered by Mr. H. B. Sargent, on the North Fork of the Smoky River. The caudal series was found by the writer, about ten miles further east, near the Smoky River.

Clidastes pumilus, sp. nov.

The smallest Mosasauroid reptile at present known is indicated by the anterior portion of a skeleton, which appears to be specifically distinct from any hitherto described, although seemingly most nearly related to the species characterized in the preceding description. Aside from the more diminutive size, however, there are several noticeable differences. In the present species, the inner third of the distal articular surface of the quadrate is much broader, and less separated by constriction from the main condylar surface. The cotylus of the articular bone, also, has a corresponding greater width. The rugose knob near the distal end of the quadrate is similar to that in the last species, but has no pit beneath it. The hook is comparatively short, and has a free compressed extremity. Its articular margin is not deflected toward the meatus. The basioccipital is longer, deeply excavated for the neural canal, and its condyle is much less elevated. The teeth are nearly round at the base, somewhat curved, and with smooth enamel. The articular faces of the cervical vertebræ are nearly vertical, and have a broad transverse oval outline, with a faint superior emargination. The free hypapophyses preserved are short, and triangular transversely.

Measurements.

Length of axis, without odontoid process,	12·3 lines.
Width of ball,	7·10 "
Depth of ball,	5·75 "
Transverse extent of distal end of quadrate,	10· "
Length of basioccipital,	13·45 "

This species was probably about twelve feet in length. The specimens representing it, so far as now known, were found by Mr. H. B. Sargent, of the Yale College party, in the yellow Cretaceous limestone, on the south side of the Smoky River, Western Kansas.

TERTIARY REPTILES.

Crocodilus ziphodon, sp. nov.

Some of the most interesting remains of fossil reptiles discovered by the Yale party, during their explorations last summer in the Tertiary beds of the Green River basin, west of the Rocky Mountains, were those of Crocodilians, several of which prove on examination to be new to science. One of these, a small animal to which the present name may be applied, presents characters which separate it at once from any known Crocodilian, living or extinct. Perhaps the most marked feature is seen in the teeth, which resemble those of some of the Dinosaurs. The crowns are much compressed, and somewhat curved, especially in those apparently pertaining to the front part of the series. The sides are smooth, the edges very sharp, and marked with fine serrations from the base to the apex. The skull was rugose, and in places deeply pitted. The quadrate, to judge from a single detached specimen found with one series of the remains, and probably belonging to them, is quite stout, with the lower surface smooth, and the distal end subtriangular in outline. The back of this reptile was covered with thick scutes, closely united by suture, and marked with numerous deep pits.

Measurements.

Length of crown of tooth,	8· lines.
Transverse diameter at base,	2·60 "
Antero-posterior diameter at base,	4·75 "
Transverse diameter of distal end of quadrate,	15·80 "
Vertical diameter, on median line,	7·90 "

The specimens here described were found by Mr. H. B. Sargent, Mr. J. R. Nicholson, and the writer, at the Grizzly Buttes, near Fort Bridger, Wyoming. The geological horizon is upper Eocene, or perhaps Miocene.*

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* This Journal, vol. i, March, 1871, p. 192, and May, 1871, p. 322.

Crocodilus liodon, sp. nov.

A second small species of Crocodile is indicated by the more important parts of a skeleton from the same Tertiary deposits as the preceding species. In this specimen the teeth are smooth, nearly round at the base, slender, with compressed points. The cutting edges are prominent and sharp, but not serrated. The jaws are quite slender. The quadrate is short, concave on its upper surface, and very flat at its distal end. The usual pneumatic foramen on the inner superior margin is, in this specimen, wanting or rudimentary. On the lower surface there is a broad longitudinal elevation, which is mainly outside the median line. The basioccipital is stout, and uniformly convex transversely. The axis is elongated, and rather slender. The hypapophyses of the cervicals are simple, compressed, and elongated. In the anterior cervicals they are directed forward, but in the eleventh vertebra, this process is perpendicular. The articular cup is here a very broad transverse oval. The dorsal scutes were articulated.

Measurements.

Transverse diameter of quadrate, at distal end,	14·	lines.
Vertical diameter, on median line,	3·90	"
Length of axis, with odontoid process,	22·25	"
Length of eleventh vertebra, from edge of cup to end of ball,	16·	"
Width of cup,	9·	"
Depth of cup,	8·10	"
Length of hypapophysis,	5·	"

This specimen was nearly, but not quite, adult. It was discovered by Mr. C. T. Ballard, of the Yale party, at Grizzly Buttes, near Fort Bridger.

Crocodilus affinis, sp. nov.

The most common fossil Crocodiles in the Tertiary beds of Western Wyoming are large reptiles, having stout conical rugose teeth, with prominent, but rather obtuse cutting edges, not unlike the teeth of the modern North American Alligator. Professor Leidy has recently described, under the name of *Crocodilus Elliotti*,* a species with these characteristics, which was found in the eastern part of the same Tertiary lake-basin; but a comparison of his original specimens, which he has kindly loaned the writer for this purpose, with the extensive material obtained by the Yale party near Fort Bridger, show clearly that there are two distinct species, about the same size, and with teeth almost identical. The two may be distinguished, however, by the premaxillaries, which in the skull described by Professor Leidy are elongate, and have, to the entire length of the skull, a ratio of about one to three. In the second species, to which the name preceding this description may be given, the corresponding parts have the approximate ratio of one to four, as shown by a very perfect skull in the Yale Museum, as well as by other remains which give all the essential characters. The symphysis in this species is quite short, and, at the posterior upper margin, is met by the anterior extremity of the splenial. The nasal bones project forward, and form a septum in the external nostril, as in the Alligator. The cervical vertebræ, moreover, have hypapophyses resembling those in that genus. The quadrate is much constricted at its distal articular end. Its lower surface is concave, with a sharp longitudinal ridge, exterior to the median line.

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* Proceedings Acad. Natural Sciences, Phil., 1870, pp. 100 and 122.

Measurements.

Length of skull, on upper surface,	13 inches,	9· lines.
Length of premaxillaries,	3 "	6· "
Transverse diameter of quadrate, at distal end,		22·50 "
Vertical diameter, on median line,		7· "

The precise relations of this species to *C. aptus* Leidy, which was described from a single cervical vertebra, cannot at present be decided.

The known specimens of the present species were collected by Mr. H. D. Ziegler, Mr. A. H. Ewing, Mr. E. Whitney, and the writer, at Grizzly Buttes, Wyoming.

Crocodilus Grinnelli, sp. nov.

This species, which was of medium size, closely resembles the preceding in the form and proportions of the quadrate, but differs from it in the more slender jaws, and the more compressed, pointed, and grooved teeth. The symphysis is also longer, and the splenial does not reach it. The basioccipital is transverse, slender and elongate, with a deep vertical groove on the median line. The axis is quite slender, and has two deep, elongated pits, side by side on the floor of the neural canal, and two, less deep and more separated, on the superior surface of the odontoid process. All the vertebræ are strongly striated on the margins of the articular faces. The scutes are free, and with few pits. The specimen here described appears not to have been fully adult, although nearly so.

Measurements.

Length of symphysis,	2 inches,	8·5 lines.
Greatest depth,		9·25 "
Transverse diameter of quadrate, at distal end,		16·75 "
Vertical diameter, on median line,		4·80 "
Length of axis, with odontoid process,		21·75 "

This species is named for the discoverer, Mr. G. B. Grinnell, of the Yale party, who found a nearly perfect skeleton on Marsh's Fork, in Wyoming. The geological horizon is essentially the same as in the three preceding species.

Crocodilus brevicollis, sp. nov.

A number of cervical and dorsal vertebræ, found together, and evidently belonging to the same individual, differ so much from any known Crocodilian remains that they may be considered specifically distinct. Among the most noticeable characters exhibited, are the relative shortness of the atlas and its attached odontoid process; and the presence, on or near the median line of the lower surface in all the vertebræ preserved, of a deep elongated pit, which has a tendency in its forward extension to produce bifid hypapophyses. The eleventh vertebra has the process thus divided. Its diapophyses are also much elongated, and entirely above the line of the neural arch suture. The articular faces are here broadly oval.

Measurements.

Length of axis, with odontoid process, ...	20·5	lines.
Depth of odontoid process, ...	9·40	"
Length of process, ...	6·30	"
Length of eleventh vertebra, from edge of cup to end of ball, ...	16·	"
Greatest distance between diapophyses, ...	21·	"

These specimens were found by Mr. A. H. Ewing, in the Tertiary beds, at Grizzly Buttes, Wyoming.

Glyptosaurus sylvestris, gen. et sp. nov.

Among the most interesting Reptilian remains discovered by the Yale party in the fresh water Tertiary deposits of western Wyoming, were several species of Lacertidæ, or land lizards, of which no fossil representative had at that time been found in this country, although more recently one species has been described by Professor Leidy from the same formation. These remains were found associated with the crocodiles and serpents, already described,* and, together with them, strikingly illustrate the remarkable development of reptilian life during the Tertiary period in one of the great tropical lakes of the Rocky Mountain region.

The specimens discovered evidently represent a peculiar genus of lizards, quite different from any known recent or fossil forms, but in the present preliminary notice only the most marked characters are given, the more exact determination and affinities of the group being reserved for the full description. The head in this genus, for which the name *Glyptosaurus*† is proposed, was covered with large osseous shields, symmetrically arranged, and highly ornamented, resembling in this respect the modern *Heloderma*. Other parts of the body, especially the ventral region, were protected by rectangular, ornamented shields, united to each other by suture, and, in some of the species, these were carinate. The teeth are pleurodont, and, in the species in which they are preserved, are round, with obtuse summits, not unlike those of *Trachydosaurus rugosus* Gray, from Australia. The frontals show, especially in front, a distinct median suture, which forms a slightly obtuse angle with their posterior margin. The articular bone projects behind the cotylus far backward and downward, resembling in this respect the corresponding part in *Varanus Niloticus*. The dorsal and caudal vertebræ have the same general form as those of *Varanus*, but show traces of a zygosphene articulation, especially in their rudimentary zygantral cavities. The tail was long, and apparently rounded. Some of the species were larger than any existing American lizards.

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* This Journal, vol. i, May. 1871, p. 322.

† Γλυπτὸς, *embossed*, and Σαῦρος, *lizard*.

The known species of the present genus may be distinguished from *Saniva ensidens* Leidy,* by the teeth, which in the latter are compressed, pointed, and have sharp cutting edges. There is, moreover, no evidence that this lizard had osseous dermal shields.

The position, form, and ornamentation of the cranial shields will perhaps afford the most convenient and satisfactory characters for distinguishing the species represented in the present collection of lacertian remains, which, although numerous, are more or less fragmentary. The present species may therefore be characterized as having, on the frontals between the orbits, shields of moderate thickness, but little elevated, with those in the middle row on each frontal broader than long. Each shield is covered with numerous small polished tubercles, crowded together with no definite arrangement. Ventral shields with the same ornamentation were found with some remains of this species, and probably belong with them.

Measurements.

Width of single frontal, at posterior margin,	7·80	lines.
Width of single frontal, between orbits,	5·30	"
Length of five posterior shields on middle row of frontal,	9·	"
Length of fragment of jaw bearing three teeth,	4·10	"
Length of ventral shield, probably of this species,	8·40	"
Width of the same,	4·75	"

The present specimens indicate a reptile about four feet in length. They were discovered by Mr. C. T. Ballard and the writer, at Grizzly Buttes, near Fort Bridger, Wyoming, in the same beds that contained the Crocodilian remains.

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* Proceedings Philadelphia Acad. Nat. Sciences, 1870, p. 124.

Glyptosaurus nodosus, sp. nov.

In this species, which was somewhat smaller than the one above described, the frontals are thicker at the median suture, and the shields between the orbits very convex. The middle row of each frontal in this region has the shields longer than wide, and subhexagonal. The tubercles on the shields are also proportionally larger, and less crowded together. The plates of the body have the same ornamentation as the cranial shields, and some of them are keeled. The species was about three feet in length.

Measurements.

Width of single frontal, between orbits,	4·50	lines.
Length of four shields on middle row of frontal,	8·60	"
Length of ventral shield,	7·10	"
Width,	3·40	"
Length of dorsal vertebra, from edge of cup to end of ball,	5·60	"
Width of cup,	3·75	"
Depth of cup,	1·95	"
Expansion of posterior zygapophyses,	5·60	"

The specimens representing this species were discovered by the writer, in the fresh-water Tertiary strata, at Grizzly Buttes, Wyoming.

Glyptosaurus ocellatus, sp. nov.

The present species, which was perhaps the largest of the lizards collected by our party, is readily distinguished from the two preceding, by the pattern of ornamentation on the cranial plates, which are very thick, united by suture, and have the tubercles arranged in concentric series. The outer row of tubercles is considerably the largest, and the next two or three successively smaller; while the center is occupied by a group of very small tubercles, with no definite arrangement. The effect of this is to produce an ocellated appearance in each shield, which has suggested the specific name. This effect is increased in one very perfect specimen by the central group of tubercles being of a lighter color.

The only specimens that can at present be referred with certainty to this species were discovered by Mr. H. B. Sargent, in the Tertiary beds at Grizzly Buttes, near Fort Bridger.

Glyptosaurus anceps, sp. nov.

A small species of lizard, quite distinct from those described above, is indicated by numerous fragmentary remains found associated with them in the same deposits. Some of the characters exhibited by these specimens point toward a different genus, but until additional material is obtained, the species may appropriately be placed in *Glyptosaurus*. The vertebræ have the cup and ball equally transverse with those of the species already described, but they are much less inclined from a vertical. The neural arch is also less elevated in the specimens preserved, and the whole vertebra is more depressed. The teeth are pleurodont. The species was about two feet in length.

Measurements.

Length of posterior dorsal vertebra, from edge of cup to end of ball,	2·80	lines.
Width of cup,	2·	"
Depth of cup,	1·	"
Expansion of anterior zygapophyses,	4·30	"

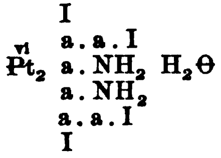
The remains on which the present description is based were collected by Mr. C. T. Ballard and the writer, in the Tertiary beds, at Grizzly Buttes, Wyoming. They are now in the Peabody Museum of Yale College, as are all the other specimens described in the present article.

Yale College, New Haven, May 5th, 1871.

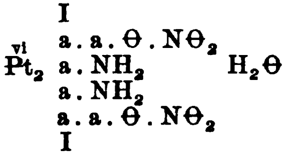
SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

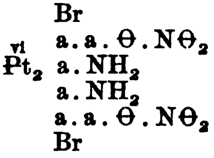
1. *On a new series of ammonia-platinum bases.*—P. T. Cleve, to whom we owe an elaborate and valuable investigation of the compounds of platinum with ammonia, has discovered a new and remarkable series in which two atoms of tetratomic platinum combine to form the hexatomic diplatinum. These compounds are formed by treating the iodide, iodonitrate and bromonitrate of Gros's base with ammonia, so that we have the formulas $Pt_2 a_8 I_4 \Theta$,[*] $Pt_2 a_8 I_2 \Theta_3 2N\Theta_2$, and $Pt_2 a_6 . 2NH_2 . \Theta_3 . 2N\Theta_2$, or rationally according to Blomstrand's views:



$$\overset{vi}{Pt_2}\begin{array}{l} I \\ a.a.I \\ a.NH_2 \quad H_2\Theta \\ a.NH_2 \\ a.a.I \\ I \end{array}$$

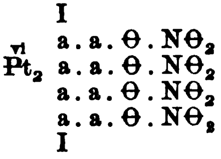


$$\overset{vi}{Pt_2}\begin{array}{l} I \\ a.a.\Theta.N\Theta_2 \\ a.NH_2 \qquad H_2\Theta \\ a.NH_2 \\ a.a.\Theta.N\Theta_2 \\ I \end{array}$$



$$\overset{vi}{Pt_2}\begin{array}{l} Br \\ a.a.\Theta.N\Theta_2 \\ a.NH_2 \\ a.NH_2 \\ a.a.\Theta.N\Theta_2 \\ Br \end{array}$$

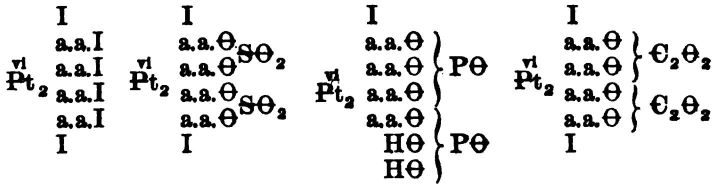
The unsaturated nitrates of the new platinum bases take up $H . \Theta . N\Theta_2$ directly, and give the saturated iodonitrate or bromonitrate:



$$\overset{vi}{Pt_2}\begin{array}{l} I \\ a.a.\Theta.N\Theta_2 \\ a.a.\Theta.N\Theta_2 \\ a.a.\Theta.N\Theta_2 \\ a.a.\Theta.N\Theta_2 \\ I \end{array}$$

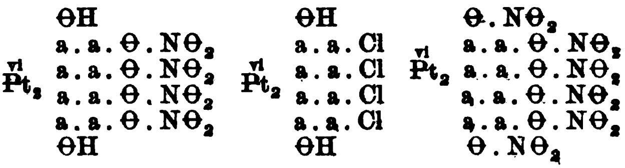
[*] In all these formulas *a* is the symbol for ammonia.

With iodide of potassium, sulphuric acid, sodic phosphate and ammonic oxalate we obtain:



$$\overset{\mathrm{vi}}{\mathrm{Pt}}_2\begin{array}{l}\mathrm{I}\\ \mathrm{a.a.I}\\ \mathrm{a.a.I}\\ \mathrm{a.a.I}\\ \mathrm{a.a.I}\\ \mathrm{I}\end{array}\qquad \overset{\mathrm{vi}}{\mathrm{Pt}}_2\begin{array}{l}\mathrm{I}\\ \begin{array}{l}\mathrm{a.a.\Theta}\\ \mathrm{a.a.\Theta}\end{array}\mathrm{S\Theta_2}\\ \begin{array}{l}\mathrm{a.a.\Theta}\\ \mathrm{a.a.\Theta}\end{array}\mathrm{S\Theta_2}\\ \mathrm{I}\end{array}\qquad \overset{\mathrm{vi}}{\mathrm{Pt}}_2\begin{array}{l}\left.\begin{array}{l}\mathrm{a.a.\Theta}\\ \mathrm{a.a.\Theta}\\ \mathrm{a.a.\Theta}\end{array}\right\}\mathrm{P\Theta}\\ \left.\begin{array}{l}\mathrm{a.a.\Theta}\\ \mathrm{H\Theta}\\ \mathrm{H\Theta}\end{array}\right\}\mathrm{P\Theta}\end{array}\qquad \overset{\mathrm{vi}}{\mathrm{Pt}}_2\begin{array}{l}\mathrm{I}\\ \left.\begin{array}{l}\mathrm{a.a.\Theta}\\ \mathrm{a.a.\Theta}\end{array}\right\}\text{Є}_2\Theta_2\\ \left.\begin{array}{l}\mathrm{a.a.\Theta}\\ \mathrm{a.a.\Theta}\end{array}\right\}\text{Є}_2\Theta_2\\ \mathrm{I}\end{array}$$

Other salts of the same series are:

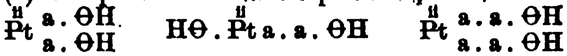


$$\overset{\mathrm{vi}}{\mathrm{Pt}}_2\begin{array}{l}\mathrm{\Theta H}\\ \mathrm{a.a.\Theta.N\Theta_2}\\ \mathrm{a.a.\Theta.N\Theta_2}\\ \mathrm{a.a.\Theta.N\Theta_2}\\ \mathrm{a.a.\Theta.N\Theta_2}\\ \mathrm{\Theta H}\end{array}\qquad \overset{\mathrm{vi}}{\mathrm{Pt}}_2\begin{array}{l}\mathrm{\Theta H}\\ \mathrm{a.a.Cl}\\ \mathrm{a.a.Cl}\\ \mathrm{a.a.Cl}\\ \mathrm{a.a.Cl}\\ \mathrm{\Theta H}\end{array}\qquad \overset{\mathrm{vi}}{\mathrm{Pt}}_2\begin{array}{l}\mathrm{\Theta.N\Theta_2}\\ \mathrm{a.a.\Theta.N\Theta_2}\\ \mathrm{a.a.\Theta.N\Theta_2}\\ \mathrm{a.a.\Theta.N\Theta_2}\\ \mathrm{a.a.\Theta.N\Theta_2}\\ \mathrm{\Theta.N\Theta_2}\end{array}$$

The analogy between these compounds and those of hexatomic cobalt will be at once evident.

In conclusion, the author gives the following view of the platinum bases at present known:

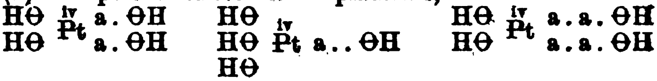
(1) Compounds of diatomic platinum,



$$\overset{\mathrm{ii}}{\mathrm{Pt}}\begin{array}{l}\mathrm{a.\Theta H}\\ \mathrm{a.\Theta H}\end{array}\qquad \mathrm{H\Theta.\overset{ii}{Pt}a.a.\Theta H}\qquad \overset{\mathrm{ii}}{\mathrm{Pt}}\begin{array}{l}\mathrm{a.a.\Theta H}\\ \mathrm{a.a.\Theta H}\end{array}$$

Reiset's second. **Platinous oxide ammonia.** **Reiset's first.**

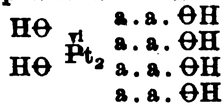
(2) Compounds of tetratomic platinum,



$$\begin{array}{l}\mathrm{H\Theta}\\ \mathrm{H\Theta}\end{array}\overset{\mathrm{iv}}{\mathrm{Pt}}\begin{array}{l}\mathrm{a.\Theta H}\\ \mathrm{a.\Theta H}\end{array}\qquad \begin{array}{l}\mathrm{H\Theta}\\ \mathrm{H\Theta}\\ \mathrm{H\Theta}\end{array}\overset{\mathrm{iv}}{\mathrm{Pt}}\ \mathrm{a..\Theta H}\qquad \begin{array}{l}\mathrm{H\Theta}\\ \mathrm{H\Theta}\end{array}\overset{\mathrm{iv}}{\mathrm{Pt}}\begin{array}{l}\mathrm{a.a.\Theta H}\\ \mathrm{a.a.\Theta H}\end{array}$$

Platinamine. **Salt of platinoxide.** **Gros's base.**

(3) Compounds of hexatomic platinum,



$$\begin{array}{l}\mathrm{H\Theta}\\ \mathrm{H\Theta}\end{array}\overset{\mathrm{vi}}{\mathrm{Pt}}_2\begin{array}{l}\mathrm{a.a.\Theta H}\\ \mathrm{a.a.\Theta H}\\ \mathrm{a.a.\Theta H}\\ \mathrm{a.a.\Theta H}\end{array}$$

In these compounds ethylamine, aniline, and doubtless other organic alkaloids may replace ammonia to a greater or less extent. —*Berichte der Deutschen Chem. Gesellschaft*, iv *Jahrgang*, p. 70. (From a letter of C. W. Blomstrand.) W. G.

2. *On the preparation of hydric phosphide for lecture experiments.*—A. W. Hofmann has given a simple and elegant method of preparing pure hydric phosphide by means of iodide of phosphonium, PH_4I, which is itself easily prepared by the following process due to Baeyer. Dry carbonic disulphide is introduced into a tubulated retort, 100 gr. of phosphorus dissolved in it, and then 175 gr. iodine added in small portions at a time. The disulphide is then to be distilled off and the last traces removed by a current of dry carbonic dioxide, the retort being gently warmed. After cooling, the condenser is to be removed from the retort and

a long, wide and thin glass tube adapted to it, terminating in a gas tube which nearly reaches the surface of the water in a flask. 50 gr. of water are then to be poured in small portions at a time upon the iodide of phosphorus through a funnel tube drawn out at the end. Every time that water is added a violent reaction ensues and iodide of phosphonium condenses in the wide glass tube, while small quantities of iodhydric acid are condensed in the water of the flask. After all the water is added, the retort is at first gently warmed, and afterward heated to low redness so as to drive all the iodide into the glass tube. On breaking the glass tube after cooling, the iodide of phosphonium is found in thick crusts like salammoniac, and with the quantities of material above mentioned amounts to about 120 gr. The iodide as thus prepared is mixed with small pieces of glass and introduced in pieces of the size of a pea into a flask provided with a rubber stopper, through which pass a funnel tube with a stop cock and bulb, and a delivery tube. If now a solution of caustic potash, of the strength of that commonly employed in organic analysis, be allowed to flow down upon the iodide, a regular current of hydric phosphide, PH_3, is evolved, which is completely under control. The gas is perfectly pure; 7·3 gr. of the iodide yield about one liter of gas. The gas is not spontaneously inflammable, but becomes so by passing through nitric acid which contains a trace of nitrous acid. Hofmann recommends as a beautiful lecture table experiment the decomposition of pure hydric phosphide by means of the induction spark passing between points of gas-carbon.—*Berichte der Deutschen Chem. Gesellschaft*, *Jahrgang* iv, p. 200. W. G.

3. *On the direct substitution of the alcohol radicals for the hydrogen in hydric phosphide.*—Absolute alcohol heated with iodide of phosphonium yields hydric phosphide, ethylic iodide and water. HOFMANN has employed this reaction in a beautiful process for obtaining the iodides of triethyl and tetrethyl-phosphonium, which consists in simply heating one molecule of iodide of phosphonium with three molecules of absolute alcohol in a sealed tube for 6–8 hours at 180° C. Under these circumstances the ethylic iodide acts directly upon the hydric phosphide to form the iodides of the substituted phosphoniums. After cooling, the tube is found filled with a beautiful snow-white, crystalline mass, which dissolves in water to a perfectly colorless solution. The crystals are a mixture of about equal proportions of the iodides of triethyl and tetrethylphosphonium. A solution of sodic hydrate separates triethylphosphine as a colorless layer of liquid. The solution then gives, on evaporation, beautiful crystals of the iodide of tetrethyl-phosphonium; the triethyl-phosphine as separated by means of a funnel is chemically pure. The iodides of trimethyl and tetramethylphosphonium were easily prepared by the same process. In like manner allylic alcohol, phenol and glycerin gave promise of a rich harvest of new results.—*Berichte der Deutschen Chem. Gesellschaft*, iv *Jahrgang*, p. 205. W. G.

4. *On a new mode of formation of Para-oxybenzoic Acid;* by **Ira Remsen**, Assistant in the Chemical Laboratory at Tübingen. (Communicated for this Journal.)—A short time since Barth[*] showed that by fusing sulphobenzoate of potassium with caustic potash oxybenzoic acid is formed. Subsequently Heintz[†] employed this reaction for the purpose of preparing oxybenzoic acid in larger quantity. The fact appears however to have escaped the notice of these chemists, that under the given circumstances paraoxybenzoic acid is likewise always formed, together with oxybenzoic acid, at times even in very considerable quantity.

I was occupied, according to the prescribed directions, in the preparation of oxybenzoic acid, which I required in an absolutely pure condition. On dissolving the first product in water, however, and allowing to crystallize, I was astonished to find that, as the solution cooled, somewhat discolored though well formed crystals, which presented the general appearance of paraoxybenzoic acid, were deposited. Recrystallized from water, these crystals became perfectly colorless and translucent. They were also more perfectly developed than at first, and the crystalline form, as well as could be determined without the aid of measurements, was identical with that of paraoxybenzoic acid. On subjecting this substance to a closer examination, its identity with paraoxybenzoic acid soon became evident. Dried at 100° the crystals became white and opaque from loss of water of crystallization. They fused at exactly 210°, and became solid at 165°. Heated above the fusing point they soon underwent decomposition. The perfect correspondence of these properties with those of paraoxybenzoic acid proves the identity beyond a doubt. The mother liquor from the first crystals yielded on evaporation a mixture, consisting of oxybenzoic and paraoxybenzoic acid, which, although crystallized out together could very readily be distinguished from each other. The latter presented itself, as usual, in the form of well developed crystals, and upon these the oxybenzoic acid had been deposited in the peculiar crystalline masses in which it is generally observed. In this case about equal quantities of the two acids had been generated.

It must be mentioned that the sulphobenzoic acid made use of in this experiment was prepared according to a method somewhat different from that usually employed. The vapors of sulphuric anhydride were conducted into a flask containing crystallized benzoic acid. As, however, after a space of time the benzoic acid became packed together in tenacious lumps, and thus resisted the further action of the anhydride, a small amount of fuming sulphuric acid was added to the mass, and the whole gently heated for a short time. On now diluting with water no benzoic acid separated.

It appeared to me possible that the method of preparation might exert an influence upon the nature of the resulting product. Hence I prepared sulphobenzoic acid according to the method described by Barth in his article (i. e. by the action of sulphuric anhydride upon fused and pulverized benzoic acid), and tried the same experiment with the potassium salt of this acid. The only difference that made itself evident in the result was that less paraoxybenzoic acid was present in the product than in the former case, though by no means an inconsiderable quantity.

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[*] Ann. de Chemie u. Pharm., cxlviii, 30.

[†] Ibid.. cliii, 326.

Finally, I subjected to the same process sulphobenzoic acid, that was prepared by simply heating benzoic acid with weak fuming sulphuric acid, and found that also in this case a mixture results, as was to be expected after the two previous experiments.

The two acids cannot be separated by means of partial crystallization. If the aqueous solution was not too dilute, the first portion that crystallized out contained, in the two last cases, the greater part of the oxybenzoic acid probably mixed with a little paraoxybenzoic acid. On evaporating the mother liquor further, about equal parts of the two acids crystallized out. The crystals of paraoxybenzoic acid could now be partially sorted out, and thus separated from the accompanying acid.

The preparation of the basic barium salt of paraoxybenzoic acid furnishes a means for an imperfect separation. This salt, as was shown by Barth,* is difficultly soluble in water, and is precipitated when baryta water is added to a solution of the neutral salt, whereas by this means no basic salt of oxybenzoic acid is produced. In this way a portion of the paraoxybenzoic acid can be obtained in a pure condition. There always remains a sufficient quantity of the salt in solution, however, to render the oxybenzoic acid useless for decisive experiments.

An attempt to employ the different properties of the cadmium salts of the two acids for the purpose of separation led to no favorable result.

It follows from the above experiments, that for the preparation of *pure* oxybenzoic acid, *crude* sulphobenzoic acid cannot be employed. It will be necessary to subject it to some process of purification. The simplest means that presents itself for this purpose is the preparation of the acid barium salt.

I am at present occupied in endeavoring to isolate and learn the properties of the sulpho-acid, the formation of which is in all probability the prime cause of the formation of paraoxybenzoic acid, and to determine the most favorable conditions for its formation. I shall also more carefully study certain uncommon phenomena, which can possibly be traced back to this, that the fact above discussed has up to the present been overlooked.

Tübingen, Germany, March, 1871.

5. *New Spectroscopic Combination;* by P. A. Secchi. (In a letter to Prof. Silliman, dated Rome, April 19, 1871).—I have the honor to announce to you the discovery of a new spectroscopic combination, by the aid of which one can see the images of the spots and of the solar protuberances with the spectral lines all at once in the same field.

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* Zeitschrift für Chemie, N. F., ii, 646.

This result is reached by two methods; 1st, by placing before the objective of the telescope, a prism as large as that which I employ for star spectra, say of six inches opening, and causing the colored image which is produced at the focus of the lens to fall upon the slit of the ordinary spectroscope.

2d. The other method, less costly, consists in placing a direct vision prism of a high dispersive power in the path of the luminous rays before they arrive at the focus, and over the slit of the common spectroscope.

By these two methods is obtained in the field of the spectroscope, the solar image formed of different colored shades, with their spectral lines, but very sharply defined with their spots and margins quite exact, so that the details of the spots can be examined as with a colored glass.

If the sun's limb falls near the line C, which as we have just said, is seen at the same time as the image of the sun's limb, we see the chromosphere and the prominences showing themselves as brilliant lines more or less elongated from the sun's limb, according to the height of the prominences. The narrower the slit the sharper the image of the spots.

Thus the protuberances are seen as brilliant lines, but their form is recognized only by linear sections as in the old method of Janssen. Nevertheless their height can be perfectly recognized and measured. by measuring the distance from where the line C becomes brilliant to that point on the sun's limb, which is upon the same normal to the limb. By opening the slit the form of the protuberances can also be recognized, but only with a loss of precision of definition. By a narrow slit the height and position of the protuberances can be recognized and measured with the greatest precision, and their position fixed with reference to the spots and faculæ, in a manner far more simple and certain than with the ordinary spectroscope.

If in a spot there is a jet of hydrogen, C is at once seen to become more brilliant or at least the darkness is diminished, and the lines of calcium and of iron become broader, &c., as in ordinary observations, but with far greater satisfaction and certainty of position.

I have observed the spectrum of the little comet of Winnecke, and I have found a band in the green similar to that in the other comets.

6. *Lessons in Elementary Physics;* by Balfour Stewart, L.L.D., F.R.S., Professor of Natural Philosophy, Owens College, Manchester. London, (Macmillan & Co.). 1870.—This little work is by no means the common-place, second hand compilation that elementary books so often are, but a careful and thorough digest of the facts and principles of Physics, by one not only a master of his subject, but himself an original investigator. Its characteristic excellence is, that it exhibits in a compact, yet elementary form the freshest aspects of physical science, particularly as related to the doctrine of energy, so successfully developed within a few

years by the labors of Thompson, Rankine, Mayer, Clausius, and others. This doctrine runs consistently through the work, and lies at the basis of the explanations of the most important phenomena of heat, sound, light, electricity, etc. Indeed this little book is one of the best elementary expositions within our knowledge of the modern views respecting energy and its transformations, and we can heartily commend it to the attention of teachers, and of all who desire, in a small compass, a clear and consistent exhibition of the outlines of modern physical science.

II. GEOLOGY AND NATURAL HISTORY.

1. *Lesquereux on Illinois Coal Plants, in the 4th vol. of the Report of the Geological Survey of Illinois.*—In the closing portion of Mr. LESQUEREUX's report on the Illinois coal-plants, the author treats of the larger groups here represented, and, while finding evidence against the existence of *Fungi* and *Lichens*, acknowledges the presence of *Conifers* (recognized by leaves and fruit, though not by woody fiber), besides the abundant *Equisetaceæ*, *Filices* and *Lycopodiaceæ*. He argues strongly for the uniformity, in character of vegetation, of the high and low land of the Carboniferous period, and concludes that there is no reason to believe that any prominent types existed which are not found in or near the coal beds. While denying that any remains of *Algæ* occur in or immediately over the beds of coal, he acknowledges their presence in sandstones and limestones near the base of the Coal-measures, both in Pennsylvania and in Indiana. His language implies what we learn to be true, that he had not seen the specimens of *Caulerpites* from Vermillion and Edgar counties of Illinois, mentioned in Prof. Bradley's reports on those counties, in the very volume under review, as occurring in a sandstone above the horizon of Coal No. 7, or at least as high as the middle of the Coal-measures. Similar forms were reported by G. C. Broadhead from the Missouri measures, though here again from the very base of the series. (See Tr. Ac. St. Louis, ii, 329, 1865.) S. W. Ely of Cincinnati also reports them from the Cumberland table-land; though, because of their character, he refers them to Devonian rocks, which do not exist there. Their position in the measures is in this case uncertain, though probably low. A locality in Indiana, not mentioned by Mr. Lesquereux, is in a heavy bed of sandstone outcropping along the bank of the Ohio river, a few miles below Cannelton.

Finding, in the ironstone nodules of Mazon creek and similar localities, various organs and parts of plants not elsewhere recognized, the author attributes their preservation to their mode of fossilization, implying that, in the softer rocks, these more delicate tissues perished before the rocks were solidified. We are more inclined to believe that their apparent absence from such beds is due merely to the greater difficulty of separating the rock from any but the broader and smoother surfaces.

"Besides two of the species described in the genus *Staphylopteris*," which has the fruit in a raceme on a separate stalk, "we have, in nodules from Mazon creek, seven fruiting species of *Alethopteris*, six of *Pecopteris*, and one *Asterocarpus*." Many others show the fruit-dots, through the tissue of the fronds, too indistinctly to be accurately made out—indicating "a proportion of fruiting branches [fronds] nearly as marked as it would be in collecting ferns of our time in a given area." *Neuropteris*, though plainly an herbaceous genus, and most beautifully and perfectly preserved, at many localities, and in great numbers, has not shown its fruiting.

Rhizomas of fossil ferns have been very rare; but we here find reported "numerous specimens of eight species." "It is therefore apparent that the organs of the ferns of the Carboniferous period were the same and in the same proportion as those of our times." "The roots of *Lepidodendron* are unknown as yet; and I believe that some species of this genus heretofore considered as branches of trees are mere creeping stems which, in some circumstances only, bear flowering stems or true *Lepidodendra*. It is the same with *Sigillaria*, the species of which I consider as fruiting stems of *Stigmaria*." "Remains of *Stigmaria* fill whole banks of fire-clay * * to a thickness of from six to fifty feet; and no remains of *Sigillaria* have ever been found in this clay in connection with them. Roots cannot live by themselves, independent of any other kind of organs, and it is certainly impossible to explain the mode of vegetation, the form, the nature of the *Stigmaria* and its action, in considering it as a root. But admitting these plants to be the floating stems of species of *Sigillaria* to which they have been sometimes seen attached, their peculiar nature and mode of vegetation become explainable, and in circumstances where they are found in the Coal-measures, they are in perfect harmony with the general vegetation of that epoch, as well as with the end which they were called to achieve. As is the case especially with our floating mosses, these floating stems of the Carboniferous epoch have the characters blended in a kind of uniformity which renders them scarcely recognizable. All the *Stigmaria* bear the same kind of cylindrical, bladdery leaves, and therefore have all, though belonging to different species, the same kind of cicatrices upon their stems, viz. a circular, double ring, with a single vascular scar in the center."

"It is evident that species of *Sigillaria* have sometimes grown in sand; and I believe that, under such circumstances, their subterranean divisions have somewhat modified their form, and have become similar to roots."

"Botanical palæontology is a peculiar science. It offers to its adepts mere fragments of organs, whose relation to a whole is mostly unknown, forcing him either to generalize and to consider in one species a number of organs which evidently pertain to plants of various kinds, or to specify and to divide under divers genera and species fragments which, if not evidently, at least often apparently, belong to the same vegetable. It is not surprising that opinions concerning these remains are often at variance and often modified, or that the student of these fossil remains becomes discouraged by the sterility of his researches."

"European palæontologists, who have especially studied the fossil plants of the Carboniferous strata, Brongniart, Göppert, Schimper, Geinitz, etc., have admitted that the distribution of these plants is modified according to the age of each bed of coal, and that, therefore, the horizontal position of the coal strata may be recognized by species peculiar to each. These views, as it now appears,* have been advanced on theoretical ground, or are based on local observations which cannot be considered as furnishing conclusive proofs; for local modifications in the succession of species of plants may be the result of mere local atmospheric or geographical changes which do not affect the characters of the whole flora, and therefore the comparative distribution of the fossil species of plants of an epoch cannot be ascertained but from the examination of this flora over the whole extent of its domain."

The author is not prepared to abandon the theory of the "stratigraphical distribution of the fossil plants of the coal," because, first, "in a theoretical point of view, it is scarcely admissible" that throughout the long succession of alternating conditions evidenced by the Coal-measures "the flora has been represented by the same species distributed in the same proportion;" and, secondly, "the fossil plants hitherto obtained are mainly the results of local researches too limited to serve as a basis for general conclusions." When more extended examinations and complete collections have been made, "we shall have sufficient proofs of a gradual change in the characters of the vegetation of the Coal-measures from the first appearance of land vegetation."

The *Lycopodia*, beginning in the Devonian "by the number of species and size of trees," attain their full development near the base of the Coal-measures, and then decrease in numbers, though very slightly in size, to Coal No. 5 of the Illinois valley section, above which "*Lepidodendra* have not as yet been found."

"From horizons above the Pittsburgh coal we know nothing as yet of the flora of our Coal-measures." But Göppert finds *Lepidodendron* as high as "the lowest strata of the Permian" in Europe.

"The fruits described under the generic names of *Trigonocarpus*, *Rhabdocarpus* and *Ptilocarpus*, have as yet been found only from the Sub-conglomerate coal strata upward to Coal No. 2. They abound in the millstone grit and the hearth sandstone as in the shale of Coal No. 2. A few fruits of uncertain affinity, and considered under the name of *Carpolithes*, have been observed higher in the measures. As yet these cases are very rare."

Of *Neuropteris* some species range from bottom to top of the measures; while others, especially those of coarse or thick nervation or texture, are characteristic of the lowest seams. *Odontopteris* runs "up to Coal No. 2" and to Coal No. 6, as is stated on page 253 of the same volume. "Large thick-leaved species of

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*** From the authority of Prof. Brongniart, in letters, 1869.**

Alethopteris, with *Callipteris Sullivanti*, are said to characterize Coal No. 2. *Sphenopteris* is considered "peculiar to the lower Coal-measures." "As representative of the higher coal strata of Illinois, there is no particular species to quote." "In the anthracite region of Pennsylvania, the highest strata are recognized by the presence of *Pecopteris arborescens*, which has not been as yet positively discovered in Illinois. * * In Europe it ascends to the Permian."

As the *Lycopodia* decreased in numbers and in size, they were "proportionally replaced by ferns."

The relation of the Coal-measures of Illinois to those of Pennsylvania, Rhode Island and Nova Scotia is indicated by the identity of numerous species of ferns. Of the common species of our eastern coal-fields, only one has not yet been found in Illinois. As regards the relation of these beds to the coals of Europe "no genus of our coal flora, except perhaps *Calamites*, can be considered as represented on both continents by species all identical or closely allied. As these points of difference, like those of affinity, have been observed from the beginning of the researches on the coal flora, and have not varied much in comparative quantity, they appear to fully corroborate the statement that, at the Carboniferous epoch, the flora which formed the constituents of the coal was, in Europe and in the United States, as different and at the same time as relatively alike, as is now the flora of the peat bogs of the two continents." F. H. B.

2. *On some points connected with the Cretaceous and Tertiary of North Carolina;* by T. A. Conrad. (From a letter to J. D. Dana, dated Greeville, Pitt Co., North Carolina.)—I have been labelling the collection of fossils at Raleigh, and am now here exploring the marl pits and bank of Tar river. I have heard so much of the mixture of Miocene and Cretaceous fossils, that I was delighted to have an opportunity to see the beds where it occurs. I thought you would like to have a sketch of them. They run from three to five feet deep, and indicate the proximity of a Cretaceous shore, not an Eocene one, for we find only Greensand fossils, and they are extremely rare. The marl is fine sand, mixed with gravel and a profusion of broken shells, some water worn, having evidently been rolled in the surf; but among these fragments is a multitude of entire bivalves and univalves not in the least abraded. In company with Col. Yellowby of this place I was walking over a marl heap, when he picked out of the marl a horse-tooth, which I think is Leidy's *E. fraternus.* Lying on the top of the marl, it had evidently been thrown up from the lower part of the bed, and is black and mineralized. From the numbers which have been found in similar situations I am forced to conclude that the horse was a Miocene quadruped; and if this tooth should prove to have belonged to *E. fraternus*, it will fix the date of the Pea-shore clay near Philadelphia. Prof. Kerr has a new *Busycon*, eight inches long, which connects the two genera *Busycon* and *Sycotypus*, for it would belong to the latter if it had a distinct

canal at the sutures, but it has only a depression there. He has also a Mastodon jaw with two teeth on each side and two straight tusks projecting from the lower jaw. This, although found on top of the marl, I believe to have been a Miocene species, drifted on the marl by the rush of waters at the close of the period.

In the drift over the marl among sand and gravel on the shore of Tar river are great numbers of shark teeth, water-worn, mixed with water-worn fragments of friable granite. There is no material variation of the beds from those of New Jersey and Maryland by which a doubt of their synchronous deposition could be sustained, and a very few species are so like the recent ones that they might pass for the same. The same colossal Pectens abound as in Virginia, only the *P. Madisonius* so abundant in Virginia and Maryland is replaced by *P. Jeffersonius* and *P. septenarius*, five or six inches in width.

At Col. Yellowby's marl pit where digging is now in progress, I found the Miocene about three or four feet in thickness, resting on black Cretaceous sand with black gravel, and containing characteristic Ripley group fossils. It is here that a profusion of Belemnites is thrown up by the laborers, over the Miocene marl heap, and give rise to the opinion that they occur in the Miocene marl.

At Snow Hill, twenty-two miles from here in Green county, the Ripley Group is finely developed, containing closely packed specimens of the Ripley species in perfect preservation.

3. *On the Earthquake at Oahu, Hawaian Islands, on Feb.* 18; by Professor W. D. ALEXANDER. (From a letter to J. D. Dana, dated Oahu College, Feb. 28, 1871.)—I herewith send you some copies of our island papers containing accounts of a severe earthquake, which was experienced here on the 19th of this month. It was the severest earthquake ever experienced on the island of Oahu within the memory of man. In fact it was quite as severe here as on Hawaii, and seems to have been felt most severely at Lahaina. As I am not quite satisfied with the accounts of it published here, I will add a few facts that I have collected.

In regard to the *time*, Flitner's astronomical clock stopped at $10^h\ 11^m\ 17^s$ P. M., Honolulu mean time, allowing for the error of the clock. In regard to the *duration* of the shock, Rev. G. Williamson, Dr. J. Hutchinson, Judge Hartwell and one or two others who timed it carefully, agree within a few seconds in making it 55 seconds. The general opinion here is that it lasted about a minute, and the same was the case at Lahaina and Hilo.

In regard to the direction of the shock, the motion was chiefly vertical with a rocking movement northeast and southwest. It was compared by some to the sensation of riding a "bucking mustang" or driving a cart over a rough corduroy road. Many stone and adobie buildings were badly cracked, particularly our school house, the large stone church, the Queen's hospital, and the court house, and the northeast and southwest walls were generally most shaken. Stone fences running northwest and southeast were thrown down, while those at right angles to this direction were not injured. Doors facing southwest were swung open, and hanging lamps were left swinging for ten or fifteen minutes in almost every instance in the same direction, viz. from northeast to southwest. Considerable crockery was broken, and heavy articles of furniture displaced. The usual roaring sound preceded this earthquake. Persons who were on board ships in the harbor report that they heard this terrible roaring sound far out at sea, and then the ships that lay farthest out were first struck and afterward those that lay at the wharves. They agree that the vessels were first drawn violently out to sea and then in the opposite direction.

Several persons of undoubted veracity insist that they saw a flash of light on Punchbowl hill the moment before the earthquake commenced. At Waialua at the north end of this island the shock was comparatively slight. At Waianae on the N. W. of this island, the earthquake was severe. Quite a landslip took place, carrying a house several rods. At Koolau, milk was thrown out of pans east and west. The schooner Annie in the channel south of Lanai was terribly shaken, and her bulwarks split amidships.

At Lahaina, as you will see by the papers, the shock was more severe than here, the ground cracked open in many places, and all the stone or adobie houses in the town were badly damaged. Rev. S. E. Bishop of Lahainaluna Seminary gives the time as $10^h\ 15^m$ P. M. The direction of the vibration was from south to north, or according to some from S.E. to N.W.

At Molokai the shock was severe, especially at the western end. The road up the great *pali* of Kalaupapa on the north side was rendered impassable.

At Wailuku, on the east side of West Maui, the earthquake was much less severe, stone walls being thrown down in some places, but no serious damage done. The *time* by my father's clock, which is set by the sun, was $10^h\ 20^m$ P. M., equivalent to about $10^h\ 15^m$ Honolulu mean time. At Makawao on East Maui the shock was slight. At Capt. Makee's, on the S.W. side of Haleakala, it was much less severe than at Lahaina. A train of molasses kettles was displaced, which was about the only damage done. The earthquake along the west coast of Hawaii was almost simultaneous with that experienced here, and about equal to it in severity. From Kohala I learn that the shock seemed to come from the *west*, that some stone walls were shaken down, but the stone church and plantation chimney remained uninjured. We hear the same story from Waimea and Kawaihae. From *Kona*, Mr. Parke writes, that the time of the shock was $10^h\ 5^m$ by his watch (which is probably within five minutes of the true time), that stone walls were thrown down, but no great damage done. At *Hilo* the earthquake was much lighter. According to Judge Hitchcock it took place at $10^h\ 15^m$ P. M., and lasted a minute.

From *Kauai* I hear that it was severe at Koloa on the south side of the island, but less severe and light on the north side at

Hanalei. No earthquake wave of any consequence is reported from any quarter.

The phenomena seem to me to point to a center of disturbance to the leeward of the islands, perhaps at the center of the circle of which the islands form an arc, and at a great depth. But as you see, our *data* are as yet very imperfect. There have been several slight shocks felt here since, on the 22d and 24th. I cannot learn that there is any unusual action going on at Kilauea or in Mokuaweoweo.

I am hoping to commence the survey of these islands next May.

4. *Note on Trimerella acuminata;* by E. Billings. (Communicated by the author).—The genus *Trimerella* was founded by me on two species, *T. grandis* and *T. acuminata;* but of the latter I had only the rostral half of the ventral valve of a small specimen. I therefore named it provisionally and stated that it differed "from *T. grandis* in having the spiral extremity much more pointed, and the longitudinal septa running all the way to the beak." (The septa here alluded to and the walls between the tubes mentioned below). Within the last few days Mr. T. C. Weston, of our survey, discovered several new specimens, among which are two exhibiting the casts of both valves in connection. It then immediately became evident that several separate dorsal valves in our collection belonged to the same species. I have, therefore, now abundant material to illustrate the species, which I shall do soon, but in the meantime propose to notice its leading characters briefly.

The ventral valve, in young specimens, is somewhat straight along the median line, but becomes more and more arched as the size increases. It is ovate, rounded in front, widest a little in advance of the mid-length, thence tapering with nearly straight sides to the beak which is narrowly rounded,—almost acute. In the substance of the shell there are two large tubes, which extend from about the mid-length to the beak. These are joined in the beak by two others, one on each side. All of these tubes are open anteriorly, but closed at their terminations in the beak. The area is large, concave and transversely striated. The dorsal valve is much shorter than the ventral, more convex and has its beak very strongly incurved. It has two tubes which extend nearly to the apex of the beak. The shell is marked with coarse concentric accretion ridges of growth. Length of the largest specimen 3½ inches, width 3 inches. The above is sufficient to show that this species is quite distinct from *T. grandis.* If a section were to be made across the beak of a perfect shell of *T. acuminata*, it would show four perforations arranged in a curve, exactly as in the similar section of the Swedish species figured by Dr. Lindström. But if the beak of *T. grandis* were to be cut across, it would show only two orifices, and they would be the homologues of the two lateral perforations in the section of *T. acuminata*, because in *T. grandis* the two central tubes do not extend into the beak, but terminate before they reach it.

Montreal, May 5th, 1871.

5. *Note on the discovery of the opercula of Hyolithes in New York;* by S. W. Ford. (Communicated by the author).—Several weeks ago, being in Montreal, I showed Mr. Billings, Paleontologist of the Geological Survey of Canada, a small collection of fossils that I had made in the Primordial rocks near this place. He pointed out to me, that among them there were the opercula of two species of *Hyolithes*. One is a minute circular species with four pairs of lateral muscular impressions, and two smaller, dorsal, all radiating from a point near one side. The other species is larger and like a *Discina* on the outside. Mr. B. showed me several specimens of the smaller species, that had been collected by Mr. T. C. Weston of the Canadian Survey last summer, in rocks of the same age below Quebec. I am informed that this is the first discovery of the opercula of *Hyolithes* yet made on this continent. I have made some observations on the rocks of this vicinity, and collected a number of species of fossils, of which I hope to give an account at an early date.

Troy, May 8th, 1871.

6. *Note on a new and gigantic Species of Pterodactyle;* by O. C. Marsh.—In addition to the Cretaceous fossils described pp. 447–453, the Yale College party obtained several specimens which indicate a huge flying reptile, apparently of the genus *Pterodactylus*. The remains belonged to two or more individuals. They are fragmentary, but some of them are quite characteristic. The distal ends of two long bones, similar in form to the tibia of a bird, are evidently portions of the peculiar metacarpal of the wing-finger. One of these, which retains the lower part of the shaft, resembles in its proportions the corresponding bone in *Pterodactylus Suevicus*. The condyles are well developed, and have a sweep of two thirds of a circle. They appear to have been originally somewhat oblique. In size and general form, they are not unlike those of the specimen figured by Owen in his Memoir on Cretaceous Reptiles, 1851 (Sup. I, Pl. IV, fig. 9–11), but there was apparently no longitudinal elevation between them. The shaft, where broken, is subtrihedral, with the posterior face concave. The bones are light, with thin compact walls. The long bones are pneumatic. The teeth are smooth, and compressed. The length of the metacarpal with the part of the shaft preserved is six and one-half inches; the fore and aft extent of the condyles fourteen lines; the transverse extent about thirteen lines. This would indicate an expanse of wings of not less than twenty feet! The species, which is the first found in this country, may be named *Pterodactylus Oweni*, in honor of Professor Richard Owen, of London. The remains now representing it were discovered by the writer, in November last, in the upper Cretaceous formation of Western Kansas.

7. *Earthquakes—Subterranean electrical disturbances.*—A few minutes before and after the earthquakes of the 17th March last powerful positive electrical currents were rushing toward England through the two Anglo-American telegraph cables, which are broken near Trinity Bay, Newfoundland. Mr. C. F. Varley, C.E., who informed us of the fact, broaches the novel speculation that some earthquakes may be due to subterranean lightning.—*Nature*, Apr. 20.

8. *Geology of Louisiana.*—The Annual Report of the Board of Supervisors of the Louisiana State University for the year ending Dec. 31, 1870, and session of 1871, contains the Second Annual Report of the Geological Survey of Louisiana to the General Assembly (of the State), by Prof. F. V. HOPKINS. It gives a brief account of the geological formations—which do not reach back in time beyond the Cretaceous, and are almost wholly Quaternary and Tertiary—and is accompanied by a colored geological map of the State. Lists of fossils of the beds are given after determinations of the species by Prof. E. W. Hilgard of the Mississippi University.

9. *Preliminary Report of the U. S. Geological Survey of Wyoming and portions of contiguous territories* (being a Second Annual Report of Progress); conducted, under the authority of the Secretary of the Interior, by F. V. HAYDEN, U. S. Geologist. 512 pp. 8vo. Washington, 1871.—Dr. Hayden during the past year continued the survey of the preceding season, by investigations from Cheyenne to Fort Fetterman, South Pass, Fort Bridger, the Uintah Mountains, Henry's Fork, Green River Station on the Union Pacific Railroad, and back, and obtained important results. In the lower range of hills which extend up to the South Pass on the south side of the Sweet Water, there was a limited area of granite with overlying Potsdam sandstone containing *Obolella nana* and a *Lingula*. Many fossil shells, vertebrates and plants were collected, which are described in special reports appended to the volume severally by F. B. Meek, Dr. J. Leidy, Prof. E. D. Cope, and Mr. Lesquereux, adding very much to the value of the volume. There is also an excellent report on the Tertiary coals of the West by Jas. T. Hodge, another on the ancient lakes of Western America by Prof. J. S. Newberry, and finally, a report on the industrial resources of Western Kansas and Eastern Colorado by Mr. R. S. Elliott.

10. *Lehrbuch der physikalischen Mineralogie;* von Dr. ALBRECHT SCHRAUF. Vienna, 1868.—Dr. Schrauf, the able author of the Atlas of Crystalline forms of Minerals noticed on page 220, issued in 1866 and 1868 volumes I and II of a work on Physical Mineralogy, which is a thorough and profound treatise on descriptive and mathematical crystallography, and the optical, thermic, and other physical characters of minerals or inorganic substances. We learn from the author that he has in preparation a third volume, which will be a companion to his Atlas of crystalline forms, and contain tables of the dimensions and angles of the crystals of the various mineral species, supplying all that is needed to make the atlas a complete exhibition of mineral crystallography.

10. *Mineralogische Notizen*, von F. HESSENBERG. No. 10 (Neunte Fortsetzunge) with 3 plates of crystalline forms. Frankfort on the Maine 1871.

III. Astronomy.

1. *On a Sunspot seen with the Naked Eye;* by Francis H. Smith. (Editorial corresp. dated University of Virginia, Apr. 19, 1871.)—On Friday, the 14th inst, shortly before sunset, I saw, with the naked eye, a large sunspot just above and to the left of the center of the disc. The atmosphere was quite hazy at the time, and one could gaze with impunity upon the sun, which appeared of a bright orange color. The spot came out with remarkable distinctness; as thin horizontal streaks of darker haze passed over the disc, Prof. Peters, who was with me at the time, saw the spot plainly.

Under the same circumstances of position, haze and color, Col. Venable and myself obtained a distinct view of apparently the same spot, which had moved in the interval to the right of the sun's center. The color of the latter was such, that a light blue glass rendered it almost invisible.

I tried in vain earlier in the day, when the sun was nearer the meridian, to detect a spot on it by looking through colored glasses.

Some time after the first occasion mentioned, I examined the sun with a small refracting telescope, and thought there appeared near the indicated position a large spot, with a smaller companion, yet in the absence of micrometric measurement, I would not have thought it large enough to be visible to the naked eye.

2. *Discovery of a new Planet.*—The 113th asteroid has been discovered by Dr. Luther at Bilk. It is of the 11th magnitude and has received the name *Amalthea.*

3. The following *table of the twenty-five small planets previously discovered* may be useful for reference.

No.	Name.	Time of discovery.	Discoverer.	Mean dist.	Angle of Eccent.		Incl.		Long. of node.		Long. per.	
					°	′	°	′	°	′	°	′
88	Thisbe,	June 15, 1866.	Peters.	2·7659	9	28	5	15	277	47	308	33
89	Julia,	Aug. 6, "	At Marseilles.	2·5505	10	22	16	12	311	33	353	14
90	Antiope,	Oct. 1, "	Luther.	3·1368	9	57	2	17	71	20	301	59
91	Aegina,	Nov. 5, "	Borelli.	2·4917	3	47	2	10	11	42	68	54
92	Undina,	July 7, 1867.	Peters.	3·1846	5	52	9	57	102	45	331	13
93	Minerva,	Aug. 24, "	Watson.	2·7536	8	5	8	37	5	4	275	1
94	Aurora,	Sept. 6, "	Watson.	3·1615	5	2	8	5	4	34	45	22
95	Arethusa,	Nov. 23, "	Luther.	3·0712	8	28	12	51	244	22	30	9
96	Aegle,	Feb. 17, 1868.	Coggia.	3·0543	8	4	16	7	322	51	164	17
97	Clotho,	Feb. 17, "	Tempel.	2·6694	14	56	11	45	160	36	65	46
98	Ianthe,	Apr. 18, "	Peters.	2·6845	10	54	15	33	354	18	147	45
99	Dike,	May 28, "	Borelli.	2·8339	14	3	14	1	41	35	239	9
100	Hecate,	July 11, "	Watson.	3·0964	9	0	6	22	128	27	307	50
101	Helena,	Aug. 15, "	Watson.	2·5731	8	1	10	4	343	35	328	41
102	Miriam,	Aug. 22, "	Peters.	2·6609	14	47	5	5	211	37	354	41
103	Hera,	Sept. 7, "	Watson.	2·7029	4	39	5	24	136	18	321	57
104	Clymene,	Sept. 18, "	Watson.	3·1798	11	23	2	53	43	47	62	12
105	Artemis,	Sept. 16, "	Watson.	2·3799	10	9	21	39	187	54	242	36
106	Dione,	Oct. 10, "	Watson.	3·1623	10	33	4	39	63	15	27	13
107	Camilla,	Nov. 17, "	Pogson.									
108	Hecuba,	Apr. 2, 1869.	Luther.	3·2134	5	46	4	24	352	20	175	4
109	Felicitas,	Oct. 9, "	Peters.	2·6941	17	27	8	3	4	56	55	56
110	Lydia,	Apr. 19, 1870.	Borelli.	2·6931	4	37	6	0	57	4	357	28
111	Ate,	Aug. 14, "	Peters.	2·5756	5	49	5	1	306	26	122	53
112	Iphigenia,	Sept. 19, "	Peters.	2·4357	7	16	2	37	324	5	337	43

It will be seen that of these twenty-five planets, fifteen were discovered in this country, six in France, four in Germany and one in India. H. A. N.

IV. Botany.

1. *Flora Brasiliensis.*—Part 50 of the great work of Martius, continued by Eichler, was issued at the close of the last year. It is occupied by Mr. Bentham's continuation of the *Leguminosæ* (viz. *Swartzieæ* and *Cæsalpineæ*), in 254 pages of letter-press, fully illustrated by 66 plates. The *Swartzieæ* form now only the ultimate tribe of *Papilionaceæ*. Among the figures are to be found one of *Guilandina Bonducella* and of a related species, now reduced to *Cæsalpinia*, of *Parkinsonia aculeata*, and of *Cassia Chamæcrista*. There are 189 Brazilian species of *Cassia*,—no small part of the genus, the much desired monograph of which, prepared two years ago by Mr. Bentham, is probably now in press. A. G.

2. *Popular Names of British Plants.*—Dr. Prior has brought out a second edition (Williams & Norgate, 1870) of this very interesting volume, with many additions or emendations. It is a treasury of curious lore, philological, antiquarian, and botanical, by one thoroughly fitted on every side for the handling of these topics. An alphabetical list of the systematic names of those British plants which have popular appellations is annexed, and under which these are enumerated. A notice of the first edition was published in this Journal, for May, 1864. One can hardly resist the temptation to make extracts from the more curious articles. A. G.

3. *Les Fleurs de Pleine Terre*, etc., par Vilmorin-Andrieux (Paris, 1870), which in the midst of terrible times has passed to a third edition, now rivals in bulk the portly *Bon Jardinier*, filling as it does 1563 duodecimo pages, illustrated by 1300 wood engravings. These, moreover, are separately issued in an *Atlas des Fleurs*, and of this an edition in English is published, forming a handsome and very useful volume. The miniature representations, sometimes of a blossom or flowering branch, commonly of the whole plant, exhibiting its port, are wonderfully effective. A. G.

4. *A Synopsis of all the known Lilies*, by Mr. Baker, one of the assistant botanists at Kew, and author of an important paper on *Liliaceæ* which was recently noticed in this Journal, is in course of publication in the Gardeners' Chronicle, London. This standard horticultural periodical, we may remark, keeps up well its scientific character, and has many interesting botanical articles and memoranda. A. G.

5. *On the Forms and Distribution over the World of the Batrachium section of Ranunculus;* by W. P. Hiern, M.A. Reprinted and revised from the Journal of Botany, 1871. With two plates.—An unusually thorough paper, maintaining the view that these plants, "considering the intricate network of connecting links that seem to break down specific characters in several di-

rections," are most philosophically regarded as forms of one aggregate species. The author adopts for this the name of *R. hydrocharis* Spenner (1829); but he certainly should have retained one of the Linnæan names, the most appropriate one of *R. aquatilis*. He proceeds to arrange and describe the *subspecific* forms, admitting 35, all but one of which bear old names. The exception is *R. Lobbii*, from California, one of the *hederaceus* group, and indicated as a variety of that species by Dr. Torrey in the Botany of Whipple's Expedition. The genuine *R. hederaceus* has recently been detected by the late Mr. Munn, near Norfolk, Virginia, in freshwater marshes, having all the appearance of being indigenous. Mr. Hiern states that it occurs in North America, but does not say where. A. G.

6. *The Rhododendron, and "American Plants;"* by EDWARD SPRAGUE RAND, Jr. Boston: Little, Brown & Co. 1871. pp. 187, 12mo.—One of those small and neat practical books, very handsomely printed, which are so attractive; and with reason, as conveying the information which the amateur cultivator needs, in a pleasant and readable form, free from all technicalities, and indeed from all scientific details. And the author writes not only *con amore*, but from abundant knowledge of Rhododendron lore and culture. So great is his success that he can affirm that Rhododendrons may be grown in New England "as easily as lilacs;" but, as subsequently qualified, only by those who will take the requisite pains in the first instance. A. G.

V. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Ventilation of Soldiers' Quarters. Special report of Acting Assistant Surgeon* B. F. CRAIG, *United States Army*—appendix to the Surgeon General's "Circular No. 4."—Dr. Craig has made a valuable contribution to our knowledge of the general subject of ventilation by his researches made at certain military posts, the details of which are given in his "Special Report" to General Barnes. We have compiled from this paper the accompanying tabular statement of Dr. Craig's results in a form convenient for reference. Dr. Craig places but little reliance on the determinations of animal matters emanating from the human body, seeing "they are so small in actual mass and of so complex and indefinite a character, that they evade to a certain extent the powers of chemical titration." He therefore confines himself chiefly to the determination of carbonic acid (Pettenkofer's method, modified slightly) and the measurements of hygroscopic moisture, temperature, &c.

The quantity of carbonic acid in air is increased about one hundred times in passing through the lungs, or from about four parts in 10,000 to four parts in one hundred of air. Mr. Edward Smith's experiments have shown that a sleeping man produces about four-tenths of a cubic foot of carbonic acid per hour, and will therefore increase the amount of it in 1000 cubic feet of air to

Tabular Statement of Experiments on Ventilation and Composition of Air in Military Barracks, made by Assistant Surgeon B. F. Craig, U. S. Army, prepared from his Report to Surgeon General Barnes.

Experiment.	Time of observation.	Tempt. Fh.		Grains moisture in 1 cubic ft. of		Apartment. Capacity in cubic ft.	Contents.			Estimation of CO_2 in 10,000 volumes of			Hourly ventilation per man in cubic ft.	Total hourly discharge of air in cubic ft.	Mode of ventilation adopted.
		Inner air.	Outer air.	Inner air.	Outer air.		Men.	Floor space pr. man.	Cubic ft. air per man.	Outer air.	Inner air.	Differ. = contamination.			
1	12.30 night, Oct. 5, '70.	69°	63°	----	----	Casemate, Fort Adams, 10,700 ft.	15	65	713	4·08	9·67	5·59	474	7,110	Open doors, &c., in summer, stove and flues in winter.
2	4 A. M., Oct. 6, '70.	----	----	----	----	Same apartment.	15	65	713	4·08	10·07	5·99	526	7,890	Same.
3	After midnight, Oct. 13–14.	70°	57°	4·62	3·56	Casement in Fort Independence, Boston, 3,927 ft.	9	39·61	436	3·68	7·18	3·50	997	8,973	Same.
4	After midnight, Oct. 14–15.	70°	52°·5	4·29	----	Casemate, Fort Warren, Boston, 8,100 ft.	11	49	540	5·49	6·26	0·77	4,950	54,450	Stove and open windows.
5	Same.	72°	52°·5	4·76	3·41	Do. do.	10	54	540	5·49	8·37	2·88	1,200	12,000	Similar.
6	No date.	59°·5	----	3·75	----	Casemate in Fort Wood, N. Y. harbor, 15,860 ft.	14	96	1,132	4·02	5·12	1·10	7,620	106,700	Fire.
7	No date.	58°	47°·5	4·02	3·29	Similar to 6.	40	33	396	4·62	9·13	4·51	767	30,700	No fire.
8	No date.	70°	47°	4·07	2·60	Frame barracks, Fort Wadsworth, 21,870 ft.	15	145	1458	4.23	6·24	2·01	1,514	22,710	3 chimneys and 2 fires.
9	No date.	----	----	----	----	Casemate, Fort Fort Hamilton, N. Y., 7,700 ft.	18	34	428	4·22	14·06	9·84	260	468	Useless.
10	----	----	----	----	----	Old frame barracks, Willett's Point.	28	58	780	2·96	4·96	1·90	780	21,640	Open slits at eaves and stoves.
11	----	----	----	----	----	Willett's Point. Similar to last.	11	----	1,500	----	10·67	----	25	275	Nothing.

the extent of four parts in 10,000, and in 2000 feet to the extent of two parts in 10,000, &c. So that from the percentage of carbonic acid we may infer, by computation, the number of cubic feet of fresh air received per hour for each man. Of course an allowance is to be made for the amount of air originally contained in the room, and this is to be determined on obvious principles, by considering the size of the room, the number of its occupants, and the length of time during which it had been occupied by them when the air was collected. Dr. Craig describes in detail the precautions taken by him to secure accuracy in the use of the methods of determination employed in his experiments, the results of which are condensed into the annexed table.

Dr. Craig's remarks with regard to the general results of his examinations, that the amount of air which writers on hygiene have held to be the minimum supply consistent with perfect healthfulness, viz. 2000 cubic feet per man per hour, was in most of the cases attained only in exceptional cases, while in some of the instances cited the deficiency is excessive.

The amount of good scientific work which has been undertaken and is still in progress in connection with the Surgeon General's office is highly creditable to the gentlemen in charge. The microscopic labors of Dr. Woodward in connection with the Army Medical Museum are already familiar to our readers. The enormous collections of morbid anatomy and surgery, preserved in the most methodical and orderly manner in the museum itself, are in process of description in many volumes of text with illustrations, parts of which are already issued. B. S.

2. *Reports of the United States Commissioners to the Paris Universal Exposition*, 1871. Published under the direction of the Secretary of State, by authority of the Senate of the United States; edited by WM. P. BLAKE, Commissioner of the State of California.—Mention of the various reports included in this series has been made in this Journal, as they have appeared. They have recently been issued in six handsome octavo volumes. The reports, the work of many able authors, contain a large amount of valuable matter on a wide range of topics, and have been well edited by Mr. Blake. The first volume contains an index to all the reports.

3. *Associations for the Advancement of Science.*—The next meeting of the British Association opens at Edinburgh on August 2d, and of the American, at Indianapolis, Indiana, on August 17th. Prof. Wm. Thomson is president of the former, and Prof. Asa Gray, of the latter.

OBITUARY.

CHARLES MAYER WETHERILL, Ph.D., M.D., died suddenly of heart disease, on the morning of March 5th, at his residence in the grounds of the Lehigh University, South Bethlehem, Pa.

Dr. Wetherill was born in Philadelphia, 4th Nov., 1825, where he graduated with first honors in the University of Penn., in 1845. In 1846 he worked at practical chemistry in the laboratory of Booth and Boyé, and during 1847 he passed eight months with

Pelouze in Paris. Thence he proceeded in Nov. 1847, to the then world-renowned teachings of Liebig, at Giessen, and there graduated Ph.D., in May, 1848. The years 1849–50–51–52, were spent in chemical investigations in his private laboratory in Philadelphia, and in giving courses of chemical lectures before the Franklin Institute. He subsequently held no public position until his election in July, 1862, to the position of chemist of the Agricultural Department of the Patent Office, which post he occupied until Oct., 1863. In 1866 he was elected to the chair of chemistry in the Lehigh University, which office he held at the time of his death.

Dr. Wetherill was a member of the American Philosophical Society, and of the Academy of Natural Sciences of Philadelphia, and of the Geological Society of Vienna. In 1853, the degree of M.D. was conferred upon him by the N. Y. Medical College.

A man of science, as such, writes his own eulogy in his works, in which alone will he live beyond the memory of his associates; and in the annals of American science Wetherill will be known when the names of many of greater temporary éclat will have been dropped from the records. He was essentially a man of work, and the list of his researches will show how honestly he devoted himself to his science, and strove—as all true men of science will strive,—to bring within the bounderies of the known, some of the extended region of possibilities and of conjectures. His title to such conquests will chiefly rest on his paper, "*Ueber neutrales schwefelsaures Aethyloxyd und dessen Zersetzungsproducte mit Wasser*," An. der Ch. und Pharm., lxvi, 117, and Proc. Amer. Phil. Soc., 1848, and in his "*Experiments with the Ammonium Amalgam*," Amer. Jour. Sci., 1865 and 1871.

Innately truthful as a man and conscientiously faithful in all he undertook, the body of his work will, we are bold to hope, stand the tests of the revision of more searching methods which will be added in the advance of knowledge. Another trait of Dr. Wetherill's character was a steady, systematic execution of his work, generally founded on plans which he had previously matured by viewing on all sides. He leaves in the Lehigh University laboratory a monument of himself, and no one can visit that institution and walk through those beautifully equipped rooms without seeing the mental characteristics which we have mentioned.

In his death science mourns the loss of a faithful servant, and friendship casts upon his grave this tribute,—in heartfelt recognition of his worth. A. M. M.

Herschel, the Astronomer, died on the 12th of May, at the age of seventy-three.

Becquerel.—M. Becquerel, who recently died in France, was not the physicist, but his son, Dumeril Becquerel.

Geological Survey of Canada; Alfred R. C. Selwyn, Director. Report of Progress from 1866 to 1869. 476 pp. 8vo, accompanied by Geological and Topographical maps. Montreal: Dawson Bros. (B. Westermaun, New York).

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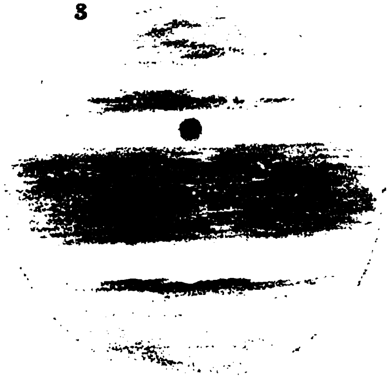

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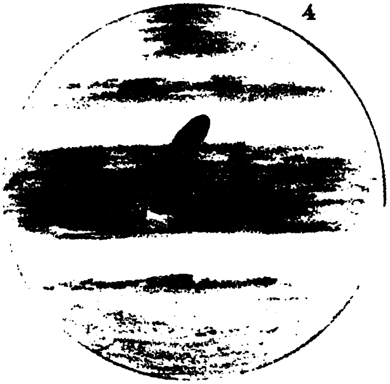

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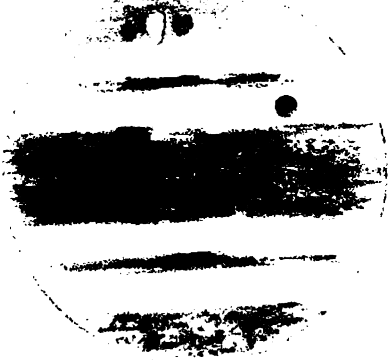

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ERRATA.

Page 20, 2d line of foot-note, for cellular, etc., *read* cellular or, etc.
" 24, line 16, for represent, *read* present.
" 24, lines 3 and 10 from bottom, for Cacteria, *read* bacteria.
" 62, line 31, for nassiform, *read* napiform.
" 62, line 33, for -petaled, *read* -petioled.
" 80, line 8 from bottom, for 1860, *read* 1869.
" 205, lines 6 and 7, the proportion of nitre referred to is that of *fused* nitre.
" 227, line 17 from bottom, for two, *read* ten.

THE

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[THIRD SERIES.]

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ART. I.—*On some phenomena of Binocular Vision*;* by JOSEPH LECONTE, Prof. of Geol. and Nat. Hist., Univ. of California.

V. *Stereoscopic phenomena.*

IT is a familiar fact that in stereoscopic pictures, properly mounted, identical points in the foregrounds of the two pictures are always a little nearer together than identical points in the backgrounds. With a pair of compasses we can, by this means, easily test whether or not pictures are properly mounted. It is evident therefore that it requires greater optic convergence to unite the foregrounds than the backgrounds of the two pictures. It is also evident that we cannot at the same time and with the same convergence unite all parts of the pictures. When objects in the foreground are united, objects in the background are seen double, the images being *homonymous;* when objects in the background are united, then objects in the foreground are seen double, the images being *heteronymous*; when objects in the middle ground are united, then both fore and background are doubled but in different directions. In looking at pictures in a stereoscope, therefore, the eyes range rapidly from fore to background and *vice versa*, uniting the objects successively, and finding the visual phenomena precisely similar in all respects to natural vision of near and distant objects, instinctively introduces the idea of depth of space. Or even looking *steadily* at any point, say in the middle ground, the depth of space is still perceived, as in nature under similar circumstances, and for the same reason, viz: that the *eye or the mind*, *instinc-*

*** For the preceding articles on this subject, see II, xlvii, 68, 153, and III, 1, 33.**

tively distinguishes between homonymous and heteronymous images, referring the one to a position *beyond*, and the other to a position *on this side* the point of sight.

This last point is so important in the theory of binocular perspective, and so at variance with the accepted view on this subject that I must dwell upon it a moment. It is now generally admitted that Wheatstone's idea of *a complete mental combination of dissimilar pictures or images is not true*, either in stereoscopic experiments or in natural vision;* but the theory which has displaced Wheatstone's, and which is now generally held, though certainly true, is, I believe, still *imperfect*. According to Brücke, Brewster, Prevost and others, the highest authorities on this subject, binocular perspective is *wholly* the result of rapid changes of convergence, or what I have called ranging of the eyes back and forth from foreground to background and *vice versa*.† I think, however, close attention to our visual perceptions will confirm the popular notion that *we distinctly perceive depth of space or the relative distance of objects while gazing steadily at one point*, even in those cases in which we are unassisted in our judgment by any other form of perspective. This is accounted for on the principle just announced, viz: that the eye instinctively distinguishes between homonymous and heteronymous images, referring the former to objects *beyond* and the latter to objects *on this side* the point of sight, or in other words, each eye knows its own images. It is true we are not usually *conscious* of making this distinction, but the same is true of the rapid changes of convergence and many other visual phenomena upon which judgments are based. The observation of Dove mentioned by Claparède‡ that stereoscopic relief is distinctly perceived by *the light of an electric spark*, and the undeniable fact that such relief is distinctly perceived by *the light of a flash of lightning*, cannot be explained by the usual theory. According to Wheatstone's well-known experiments in 1835, the duration of an electric spark from a Leyden jar is $\frac{1}{24000}$ (·000042) of a second.§ The later experiments of Fedderson in 1858, and of Prof. O. N. Rood in 1869, give nearly the same results; the former ·00004 of a second, and the latter from ·000022 to ·000050* depending upon the degree of the charge and the length of the spark. The duration of a flash of lightning, according to Rood,† is about $\frac{1}{500}$ of a second. Now it is obviously impossible that in $\frac{1}{24000}$ or even in $\frac{1}{500}$ of a second the eye can change its convergence so as to adapt it consecutively to single visions of different objects at different distances. The perception of stereoscopic relief under these circumstances is therefore inexplicable on any other theory than that which I propose. The *true theory* of binocular perspective seems, therefore, to be this: *the eye, even when fixed steadily on one point, perceives the relative distance of objects by means of double images, as already explained; but this perception is made much clearer by the ranging of the eyes back and forth, uniting successively the images of near and distant objects.*

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* Mr. Townes in the elaborate paper "on the physiology of vision" already alluded to in my last paper, (III, 1, 33,) devotes much time and many experiments to the subversion of this view, under the impression that it is still the universally accepted view.

† See an admirable review of the whole subject by Claparède, Bib. Univ. Archives des Sci. Nouv. Per., vol. iii, p. 138 and seq.

‡ Ibid. p. 155.

§ I give Wheatstone's result on the authority of De la Rive, (vol. ii, p. 184, trans.) and of Daguin (vol. iii, p. 518, trans.). It is somewhat remarkable that nearly all writers on physics give Wheatstone's result as a little less than $\frac{1}{1000000}$ instead of $\frac{1}{24000}$ of a second. Prof. Rood in his recent admirable researches on this subject has unfortunately fallen into the same mistake. The $\frac{1}{1000000}$ of a second does indeed occur in Wheatstone's paper, but it is the time occupied by the electric current in passing from one interruption of the wire to

If the pictures on a stereoscopic card be *reversed*, i. e. the right picture placed on the left side and the left picture on the right side, *the binocular perspective is also reversed*, the objects in the foregrounds being seen at a distance, and objects in the backgrounds near at hand; in other words, the foregrounds of the pictures become the background of the scene, and the backgrounds of the pictures the foreground of the scene. The reason is obvious. By changing the pictures, identical points in the backgrounds become nearer together than those of the foregrounds. Thus greater optic convergence is necessary now to combine objects in the backgrounds of the pictures than in the foregrounds, and therefore by the principles of binocular perspective the former will appear nearer than the latter. These facts are illustrated in figs. 1 and 2, in which *S S* is the septum of the stereoscope, *r S* the right and *l S* the left picture, R and L the right and left eye, N the nose, a*a* identical points in the foregrounds, b*b*‡ identical points in the backgrounds of the right and left pictures respectively, and A and B the places behind, where a*a* and b*b* are seen. Fig. 1 represents the result where the pictures are properly mounted, and fig. 2 when reversed. By comparing the two figures the reverse perspective and its cause becomes evident.

This inverse perspective was long ago pointed out and explained by Wheatstone, and stereoscopic pictures are often made expressly to exhibit it. I am not aware, however, that any one has drawn attention to the beautiful, and in some respects

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another—*the time between the occurrence of the sparks and not the duration* of the sparks; it is measured by the *arc of displacement* of the image of middle spark, not by the *arc of elongation* of the images of the sparks. I am indebted to my brother Prof. John Le Conte for having directed my attention to this mistake.

* This Jour., II, vol. xlviii, p. 153. † This Jour., III, vol. i, p. 15.

‡ The italic *a* and *b* are *underlined* in the figures.

peculiar, results both of natural and inverse perspective, produced by the combination of stereoscopic pictures with *the naked eye* by *squinting.* I find that I am able to combine stereoscopic pictures in this way, quite as easily or even more easily than with the stereoscope. The results by this mode of combination differ from ordinary stereoscopic results in several respects. 1st. In combining on *this side* the plane of the pictures by squinting the *right-eye* image of the *left* picture, combines with the *left-eye* image of the *right* picture; while in combining *beyond* the plane of the pictures as in ordinary stereoscopic experiments, it is the right-eye image of the *right* picture, and the left-eye image of the *left* picture which combine to form the binocular result. This is evident on comparing fig. 1 with fig. 3. 2d. Besides the binocular result there are of course homonymous monocular pictures on the right and left; while in the stereoscope these monocular pictures (which, however, in this case would be heteronymous) are cut off by the septum. 3d. The binocular result, instead of being magnified as in the stereoscope, is seen in exquisite miniature and has all the charm of miniature pictures. 4th. The depth of perspective is proportionally less than in combination beyond the card. 5th. The perspective is always the *reverse* of that given by the stereoscope, and therefore, in order to produce the same perspective the *mounting* must be reversed.

If ordinary stereoscopic photographs be reversed and the pictures be then combined *with the naked eye* by squinting, the stereoscopic effect is as perfect as can be imagined. Miniature houses, gardens, lawns, statuettes, fountains, &c., such as Gulliver might have seen in the land of Lilliput, are presented *in perfect perspective.* I have often amused myself by changing the mounting of stereoscopic pictures in order to enjoy the exquisite effect. Of course in order that there should be perfect definition of the objects, there must be complete dissociation of the focal and axial adjustments, as already explained in my first paper.* If stereoscopic pictures are combined by squinting *without reversing the mounting*, then of course the *perspective is reversed.* These facts are represented by figs. 3 and 4. Fig. 3 represents the combination of fore and background when the mounting is suitable for the stereoscope. By comparing this with fig. 1, the reversal of the perspective is obvious. Fig. 4, represents the combination of fore and background when the mounting is changed. It will be observed that the perspective is true.

In combining with the naked eye stereoscopic pictures mounted in the usual way, it is not always easy, sometimes it is not possible, to bring out the inverse perspective distinctly. The reason is that it violates other kinds of perspective, and sometimes sets at defiance the known properties of bodies. It is most distinct when other kinds of perspective are least distinct. In natural vision there are many kinds of perspective, or many modes of judging of the relative distance of objects; viz. *aerial* perspective or increasing dimness with increasing distance; *mathematical* perspective or decreasing size with increasing distance; change of focal adjustment necessary for *distinct* vision of near and distant objects; change of axial adjustment necessary for *single vision* of near and distant objects. The first three of these are *monocular*, the last is *binocular*. The painter can give only the first two. The stereoscope gives also the last, and its surprising effects are due to this cause. In natural vision alone all kinds concur. Now in reversing the binocular perspective we do not affect the other kinds. There is therefore, a discordance between this and the other kinds, and when they exist it must overpower them. This it cannot do when the mathematical perspective is strongly marked. Thus the curious effects of inverse perspective is best seen when the other forms of perspective, particularly the mathematical, are least marked. It is impossible to see it in cases of long buildings or long rows of buildings taken in perspective. In such cases the mathematical overpowers the binocular perspective. But in buildings and grounds seen directly in front it is very evident. I now combine with the naked eye stereoscopic photographs, taken directly in front, of a building, the profile outline of which is given in fig. 5; as soon as by rectification of the focal adjustment the image becomes clear, the inverse perspective comes out distinctly as represented in fig. 6. The roofs *a a* and the lawn *b* slope away downward as if we were looking at them from beneath. They are transparent, however, for the grass on the lawn stands upright. The column *c* is seen beyond the house as if through a transparency or as if the wall of the building was wanting in that part. I now try a scene in Lombardy taken on glass. Viewed in the stereoscope a village is seen in the distance and a row of poplars far in front with their straight trunks projected against the houses of the village; combined by squinting the *village* is seen *in front* and the *trees* through the houses far *in the distance*. Next I try stereoscopic pictures of the full moon. In the stereoscope it is egg-shaped with the end of the egg toward the observer; combined with the naked eye, it is a *shallow concave* very perfect and beautiful. In a picture of Paris viewed in the same way, the mathematical perspective is entirely overpowered by the binocular perspective, and the city is seen sloping away downwards as if seen from beneath through a transparent ground, but with the smaller

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* This Jour., II, vol. xlvii, p. 68.

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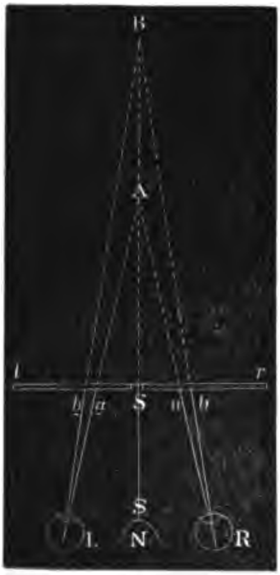
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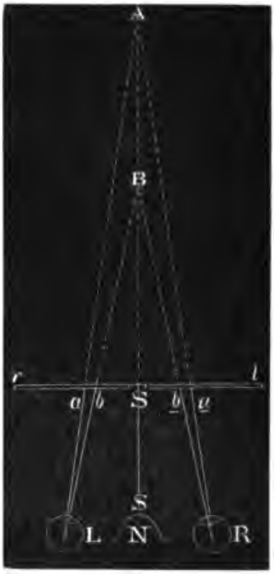
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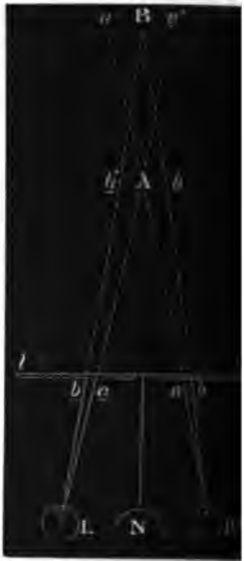
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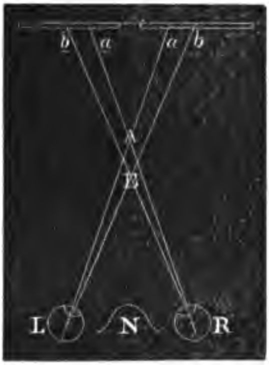
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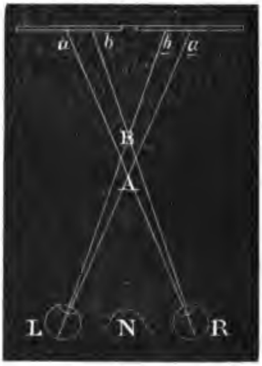
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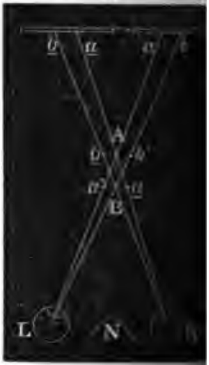
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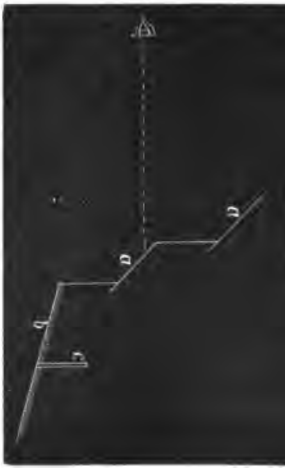
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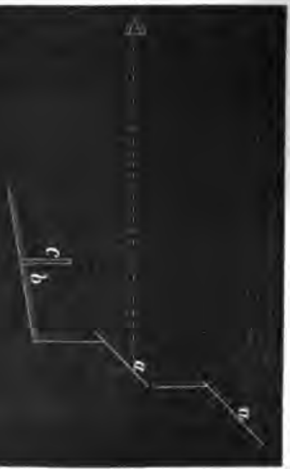
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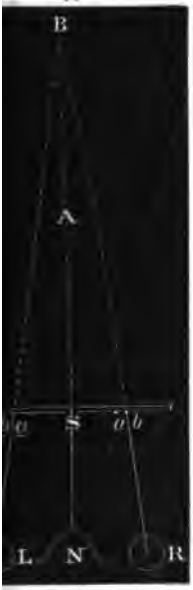

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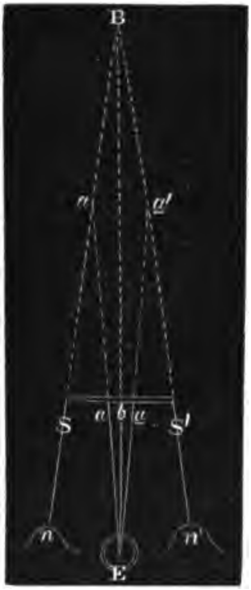

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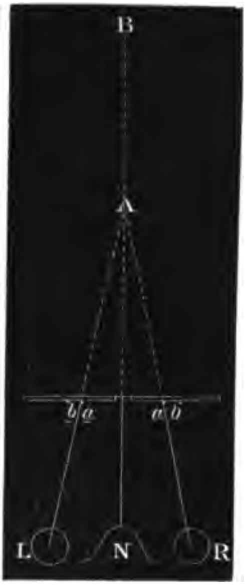

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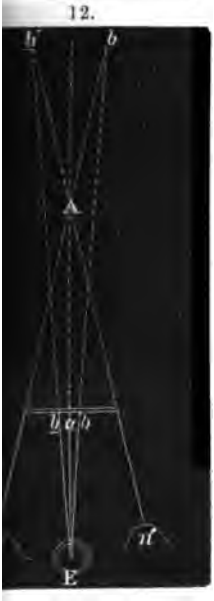

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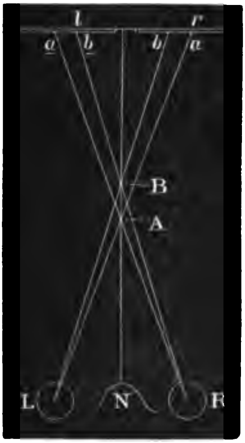

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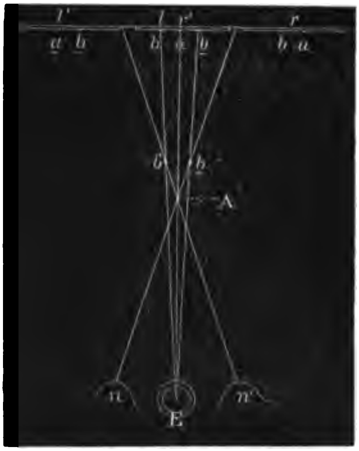

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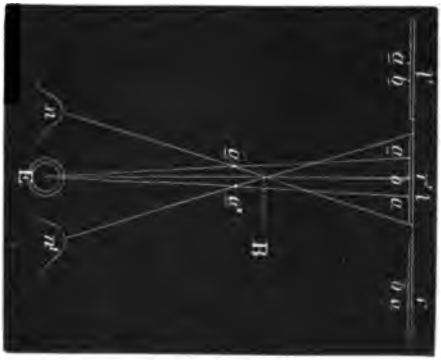

houses above and nearer, and the larger farther away in the distance.

On combining in a similar manner one of those skeleton polyhedra so frequently used to illustrate stereoscopic principles, I find the stereoscopic effect equally perfect as with the stereoscope except that the nearer triangular face is *smaller* than the farther one instead of the contrary. Nothing can exhibit more clearly than these experiments, the entire distinctness of the binocular from every other kind of perspective.

Stereoscopic pictures may be combined with the naked eye, *also beyond* the plane of the card in the manner of a stereoscope; but there are two difficulties in the way of success in this kind of combination. In the first place in most stereoscopic pictures, identical points are farther apart than the eyes, and therefore, cannot be combined beyond the pictures without the aid of lenses or prisms. In the second place, even if the pictures are not farther apart than the eyes, and may therefore be thus combined, the dissociation of the focal from the axial adjustment, as already explained in my first paper* is difficult and imperfect, and the combined picture therefore is not clear.

I wish now to apply the method proposed in my last article, in the representation of stereoscopic phenomena. The usual method, which I have used in figs. 1, 2, 3, and 4, because it is familiar, represents perfectly the position of objects seen *single* and therefore their relative distance or the depth of space, when the eyes are directed upon them consecutively; but cannot represent the position of *double images* in the stereoscope any more than it can in natural vision. Fig. 7, gives the mode of representing by the usual method. A R, A L is the position of the optic axes when objects a *a* in the foregrounds are combined at A and b*b*′† the position of the double images of b*b*, seen at the same distance as A; B R, B L the direction of the optic axes when objects b*b* in the backgrounds are combined and seen at B and a*a*′, the apparent position of a*a* at the same distance as B. Fig. 8 gives the same when pictures are combined by squinting.

Now it is evident that this mode of representation is not true, for we *do not* refer b*b*′ to the same distance as A, when we look at A, nor a*a*′ to the same distance as B when we look at B. The whole stereoscopic effect would be lost if we did. On the other hand my method of representation gives the true apparent positions of the double images as we now proceed to show.

When we gaze through a stereoscope the two pictures seem to slide inward over each other until they unite to form a single picture in the middle. The septum of the stereoscope is therefore doubled heteronymously, and forms two parallel planes or walls bounding the field of view on either side. Between these two bounding planes, the eye (combined eyes) from its apparent central position seems to look straight forward upon the scene. As soon as we converge the eyes upon any object in the scene, the two septa or bounding planes seem to converge to the same degree, and if produced would meet at the point of sight, if this be in the median line, or in any case at the *distance* of the point of sight. As the point of sight however, is always far beyond the septa, practically the septa will seem nearly or quite parallel. Fig. 9 gives the actual relation of parts and the position of the visual lines when b*b* objects in the backgrounds of the pictures are united and seen at B; fig. 10 gives the visual result. The two pictures are slid over each other each a half interocular space until b*b* fig. 9, unites in the middle *b* fig. 10, and a*a* slide by each other and become heteronymous. The combined picture *b* is seen at B (fig. 10), because we are conscious of an optic convergence suitable for that distance, or in other words we are conscious of *looking* at that distance. In this mode of representation the position of B, when it is on the median line, is determined by the intersection of the double septa or median lines *n S*, *n′ S′* produced; and the position of a*a′* of the scene is determined by the intersection of the lines from the eye through *aa* of the card (ray lines), with the median lines *n S*, *n′ S′*. It will be observed that these double images occupy precisely the position of those of an object at A fig. 9. Fig. 11, gives the relation of parts and the direction of the optic axes, when objects a*a* in the foregrounds of the pictures are combined and seen at A, and fig. 12, the visual result. To combine a*a* (fig. 11), b*b* do not slide by each other, and are therefore homonymous, and are therefore referred beyond A and seen at b*b′* (fig. 12) precisely as if they were the double images of an object situated at B (fig. 11). In the representation (fig. 12) the exact position of b*b′* of the scene, is determined as before by the intersection of median lines with the *ray lines.*

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* This Jour., II, xlvii, pp. 73 and 76.

† As in my previous article dashed letters mean *left-eye* images.

The phenomena of combination by squinting is represented in figs. 13, 14, 15, of which fig. 13 represents the actual relation of parts, and the direction of the optic axes when foregrounds and backgrounds of the pictures *r* and *l* are consecutively combined. In this case the mounting is supposed to be changed so as to make the perspective natural. Fig. 14 represents the visual result when the foregrounds are united, and fig. 15, when the backgrounds are united. The positions of the double images in the scene are determined as before. In the case of combination by *squinting*, the two images of the card do not slide over each other *inward*, as in the stereoscope, but *outward*; so that, as already stated, the *right-eye* image of the *left* picture covers the left-eye image of the *right* picture, to form the binocular picture or scene; while homonymous images of the right and left pictures are seen to the right and left. I have represented this in figs. 14 and 15, where *r* and *l* are right and left pictures as seen by the right eye, and *r′ l′* the same as seen by the left eye. By careful inspection, after what I have already said, the figures will explain themselves. It is true, this mode of representation is complex, and, for those unaccustomed to binocular experiments, perhaps difficult to understand; but it has the advantage of truly representing the somewhat complex visual phenomena.

Oakland, Cal., March 20, 1871.

ART. II.—*On three Masses of Meteoric Iron, from Augusta Co., Virginia;* by J. W. MALLET, Professor of Anal. and Applied Chemistry, University of Virginia.

NEARLY two years ago I learned that a lump of iron, which from the description given of it I supposed to be meteoric, had been turned up by the plough in Augusta Co. in this State, and soon afterwards I obtained possession of this specimen by the kind assistance of Hon. J. B. Baldwin of Staunton. It proved to be beyond question a meteorite, weighing about 56 lbs.

A few months later, I saw at the Annual Fair of the State Agricultural Society in Richmond, a second mass, of smaller size, weighing about 36 lbs., which had come from the same county, and was exhibited along with some iron ores by Maj. Jed. Hotchkiss of Staunton. Learning from me that I was about to examine and analyze my own specimen, and was anxious to compare it with the other found in the same part of the country, Maj. Hotchkiss was obliging enough to lend me the latter, and to permit me to cut off enough for analysis.

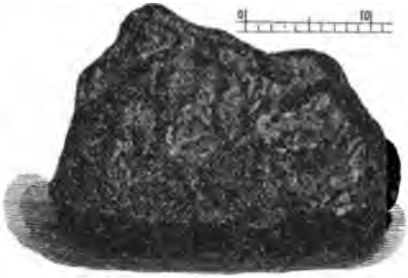
Quite recently he has placed in my hands a third specimen—also from Augusta Co.—weighing but about 3½ lbs.

I shall speak of these three masses as No. 1, No. 2, and No. 3, in the order in which they are mentioned above; No. 1 being my own specimen, and Nos. 2 and 3 those of Maj. Hotchkiss.

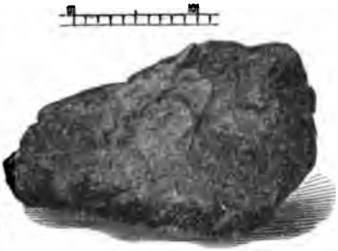
All three present quite the same general appearance. They are of a very irregular pear shape, one end of each mass being larger and more rounded than the other—the smaller end of each is somewhat flattened, but by concave surfaces, in one direction. No. 1 was more massive and rounded than the others—No. 2 most flattened—the latter had some rude resemblance in shape to a shoulder of mutton. The dimensions of the masses before cutting were as follows:

	No. 1.	No. 2.	No. 3.
Maximum length, ...	28 centimeters	27 c. m.	11 c. m.
" width, at large end,...	21 "	10 "	9 "
" " at small end, ..	17 "	19 "	5 "
" thickness, at large end,.	13 "	13 "	8 "
" " at small end,	11 "	5 "	3 "

No. 1.

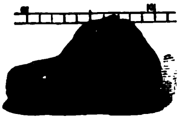


No. 2.



A pretty good idea of the shape and size may be obtained from the accompanying figures, from photographs of the original specimens with attached scale. The exact weights before cutting were,

No. 3.



No. 1.	No. 2.	No. 3.
25,429 grams.	16,441 grams.	1,644 grams.

the masses being entire, nothing having been previously detached from any one of them.

The surface of each of the masses is rough and irregular. At some points, which have been rubbed, the iron exhibits its metallic luster, and traces of its crystalline character may be observed, but nearly the whole surface is covered with a dark brown crust, consisting essentially of hydrated ferric oxide, which varies from about an eighth to a third of an inch in thickness. This crust is hard, and pretty firmly adherent. On exposure to moist air a rusty liquid exudes in drops from numerous points upon the surface, and in this watery liquid chlorine, iron (chiefly as ferrous chloride), and nickel were detected. The masses are of course magnetic, and on examination give evidence of feeble magnetic polarity, with multiple poles.

The union of hardness and toughness in the iron makes it quite difficult to cut, and in attempting to obtain with the planing machine a slice of considerable size the ordinary cutting tools were blunted and broken; it was found necessary to drill a row of holes and connect these by a cut made with the planer.

The specific gravity was taken for Nos. 1 and 2 with solid pieces of about 140 grams and 95 grams, respectively, cut from the interior of the masses, and for No. 3 with about 10 grams of clean shavings (from the planer) in a specific gravity bottle. The results were,

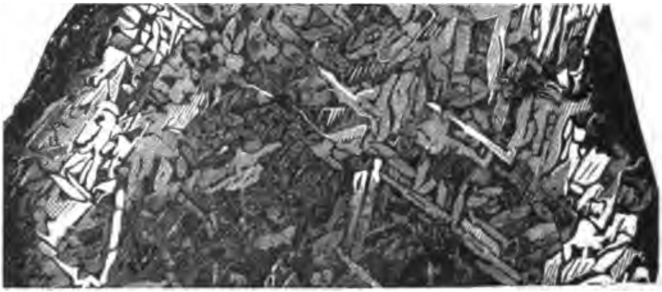
	No. 1.	No. 2.	No. 3.
Specific gravity, at 15° C.	7·853	7·855	7·839

The interior structure of the iron is compact and highly crystalline, of much the same general character throughout, but a few small grains and streaks of a brownish yellow mineral were noticed, which on being picked out and examined proved to be troilite. There are, however, minute fissures running through several portions of the metal.

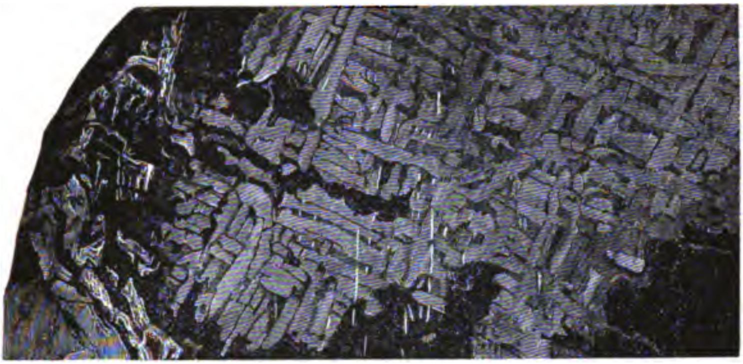
Traces of the Widmannstättian figures may be detected upon a polished surface even without the aid of an acid, and when the iron has been etched by nitric acid the markings are exceedingly distinct and beautiful, fully as much so as in any specimen of meteoric iron I have ever seen. The general appearance is a good deal like that of the iron from Lenarto in Hungary, and some of the Mexican specimens. In the mass No. 1, upon the principal cut surface, narrow, well-defined bands of alternate nickel-iron and Schreibersite are parallel or intersect each other at angles of about 60° and 120°; in the figures on the principal surface of No. 2, the angles of intersection more nearly approach 90°; on the much smaller cut surface of No. 3, the figures are somewhat more irregular, but the angles approach 60°. By etching surfaces obtained in other planes it was rendered evident that the difference of appearance is merely due to looking at different projections of the same crystalline structure. The accompanying engravings, taken from photographs, exhibit the results of etching these specimens.

The metal soon rusts upon cut surfaces, especially where the exudation of chlorine occurs, and this renders more distinctly visible the slight fissures which penetrate the interior.

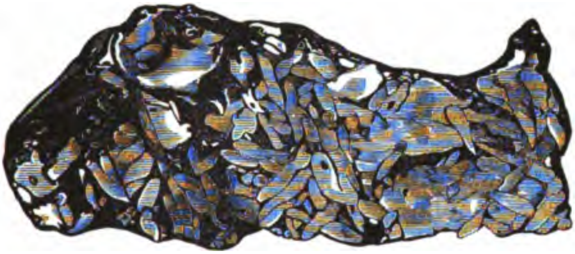
No. 1.



No. 2.



No. 3.



The iron is not passive, though very easily rendered so by nitric acid. It reduces copper rather slowly from the sulphate, and if the whole surface be covered by the latter metal and then washed under a stream of water, rubbing hard with the hand or a cloth, a part of the copper comes off very easily, leaving the remainder firmly attached and reproducing very beautifully the Widmannstättian figures; obviously a case of galvanic deposition, the Schreibersite being the electro-negative solid and receiving the coating of copper.

By the prolonged action of acid delicate white laminæ ot Schreibersite are brought into view, which if completely detached are found to be flexible and strongly magnetic.

The following are the results of chemical analysis.

	No. 1.	No. 2.	No. 3.
Iron,	88·706	88·365	89·007
Nickel,	10·163	10·242	9·964
Cobalt,	·396	·428	·387
Copper,	·003	·004	·003
Tin,	·002	·002	·003
Manganese,	trace	----	trace
Phosphorus,	·341	·362	·375
Sulphur,	·019	·008	·026
Chlorine,	·003	·002	·004

	No. 1.	No. 2.	No. 3.
Carbon,	·172	·185	·122
Silica,	·067	·061	·056
	99·872	99·659	99·947

These numbers are so closely accordant that there can be no doubt of the masses being essentially identical in chemical composition.

The nickel and iron were separated, in a cold and quite dilute solution, by means of carbonate of baryta, and the precipitates obtained were carefully tested as to purity before the weights were finally accepted as correct.

Considerable quantities of material were used for the determination of the minor constituents. Particular attention was given to the identification of the minute quantity of tin present, as Professor J. Lawrence Smith has lately mentioned* the fact, that he has never found this metal in the course of numerous analyses of meteoric iron. The precipitate with sulphuretted hydrogen, which contained the tin and copper, was in each case obtained from a solution of more than a hundred grams of the iron.

I feel satisfied that the chlorine is not of meteoric origin—not an essential constituent of the original masses—but has been derived from the soil in which the iron has lain imbedded. The exudation of watery drops containing metallic chlorides is observable only at points on the outside and on cut surfaces along the lines of fissures communicating with the outside. Although chlorine is mentioned above as found in the general analysis of the planing machine shavings, I failed altogether to detect it in a specially selected solid piece of some fifty grams taken from a part of No. 1 destitute of fissures or flaws.

The siliceous residue is set down as silicic acid, but some of it seems to have in reality existed as silicide of iron. A part of this residue having been examined with the blowpipe to identify it as silicic acid, another portion was looked at with a magnifying power of 250 to 500 diameters, and in polarized light was seen to consist of an amorphous powder, and rounded, transparent grains of very small dimensions, for the most part from ·0025 to ·0100 millimeter in diameter, of well-marked doubly refracting character.

It seems in the highest degree probable that these three masses of meteoric iron represent portions of a single fall from the heavens, agreeing so closely as they do in external character and appearance, in density and internal structure, and in chemical constitution; having, moreover, all been found at but short distances from each other. The precise localities from which they came are as follows:

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* This Journal, II, xlix, 333, (May, 1870).

No. 1, from a spot on the land of Mr. Robert Van Lear, about five miles (a little East of) North from Staunton, in 38° 14′ N. lat. and 79° 01′ W. long.

No. 2, from the land of Mr. M. Fackler, about one mile to the Southeast of the locality of No. 1.

No. 3, about half a mile still further Southeast, or rather a little North of a N.W. and S.E. line passing through the last named locality.

It will be interesting to watch for the possible detection of other masses in the same neighborhood.

This makes the fourth recorded instance of meteorites found within the State of Virginia, the three preceding having been,

1. Meteoric stone, which fell in Chesterfield Co., June 4th, 1828, (this Jour. I, xv, 195 and xvi, 191).
2. Meteoric iron, found in Grayson Co., described by Prof. Rogers of this University in 1842, (this Jour., I, xliii, 169).
3. Meteoric iron, found in Roanoke Co., and described by Prof. Rogers in 1842, (this Jour., I, xliii, 169).

University of Virginia, March 27, 1871.

ART. III.—*The Glacial Features of Green Bay of Lake Michigan, with some observations on a probable former outlet of Lake Superior;* by N. H. WINCHELL, of the Geological Corps of Michigan.

THE topographical features of the region of Green Bay, are strikingly dependent on the geological structure as acted on by glacial forces. The west coast is low, and in but few places can the underlying rock be seen above the drift deposits. The immediate shore varies but little from the regular trend of the outcropping Trenton limestone. But two considerable bends occur on the west coast; and they are caused by alluvial deposits at the mouths of the Peshtigo and Menominee rivers. Across these rivers the bearing of the Trenton limestone is disclosed in the rapids which occur a few miles above their mouths. At the mouth of Little Bay de Noc the course of the coast line takes a direction nearly N. and S., an interesting fact, the special significance of which will be noticed further on.

The east coast is in the same way dependent on the line of bearing of the Niagara limestone; but, very unlike the west coast, it is frequently indented by bays which by their great depth of water form beautiful ship harbors. Of these Sturgeon Bay is the most remarkable, and may be taken as a type of all the deep indentures occurring on the east shore of Green Bay. The vast escarpment of Niagara limestone rises sometimes immediately from the water, but more frequently it passes a short distance from the shore, forming an almost continuous rock-barrier 150 to 200 feet in height from the head of Great Bay de Noc to near the south end of Green Bay. It also underlies the whole table-land of the peninsula which encloses Green Bay, and affords by its natural dip a gentle descent E.S.E. toward Lake Michigan. Hence the entire drainage of the peninsula is into that lake, the "divide" being along the shore of Green Bay. The east and west shores afford another noticeable contrast in the comparative depth of the off-shore water. By inspecting the charts of the U. S. Lake Survey the recorded soundings along the west side show very shoal water, while on the east side the "ten-fathom line" runs near the land, frequently uniting with the shore-line, the entrances to the little bays being uniformly very deep. The passage through Port des Morts is 21 fathoms, north of Louse island 24 fathoms. The mouth of Eagle harbor is 11 fathoms, of Ellison's bay 12 fathoms, and of Hedgehog harbor 17 fathoms. The average depth of Green Bay is 16 to 18 fathoms.

The uniformity in the direction of these bays is another remarkable fact. They indent the peninsula in a southerly or southeasterly direction. On the contrary the bays on the opposite side of the peninsula, and opening into Lake Michigan, have a very uniform direction northerly or northwesterly, complementing those opening into Green Bay in such a way, that the peninsula is in several cases almost intersected by their near inosculation.

The barrier of the Niagara limestone is broken through at each of these bays, and its broken off ends form perpendicular and bald bluffs which face each other across their entrances, and rise to the height of 75 to 175 feet. Government and Hibbard's bluffs enclose Sturgeon bay. The former has a height of 115 feet, the latter about 80 feet. Eagle Bluff is on the south side of Eagle harbor and has a height of 149 feet 10 inches. Its counterpart on the north side is about 60 feet. Garden Bay in Great bay de Noc is another example of the same phenomenon. The Niagara barrier is more broken down between Port des Morts and Pt. de Morts and Pt. de Tour than at any other place. Projecting southward, the peninsula which encloses Great bay de Noc and terminates with Pt. de Tour, is a counterpart of that which encloses Green Bay; and the whole interval between Door Bluff on the south and Sag Bluff in Great bay de Noc on the north, is but an enlarged illustration of the phenomena already described. In this case the Niagara limestone is so completely broken down as to admit the waters of Lake Michigan, the Potawatamie islands, which lie in that interval, being its only parts remaining above the level of the lake.

Glacial striæ and polished surfaces at the head of Green Bay have a direction N. 34° E. coinciding with the axis of Green Bay. In the bay north of Sag and Burnt Bluffs, in Great Bay de Noc, they run about N.W. and S.E.

Among the glacial features may be mentioned the general aspect of the east shore of Green Bay and of Great Bay de Noc. Those deeply cut bays before mentioned must be regarded as of the nature of fiords, and doubtless owe their origin to spurs from the main glacier which excavated the Green Bay valley. The Sturgeon Bay spur was probably aided in taking its more easterly trend by a local glacier which contemporaneously descended the valley of the Uenominee. By their uniformity of direction a tendency is indicated in the main glacier to move in a more southerly direction than the general direction of Green Bay requires. In fact the islands between Port des Morts and Pt. de Tour exhibit the effect of intense glacier action in a direction N. and S. Long trails of detritus from these islands shoal the water for several miles southward; but toward the north the water becomes suddenly very deep.

A natural result of this spurring off from the main glacier is exhibited in the westward tendency of the coast line immediately south of the bays thus formed. The diversion of that portion of the moving glacier which passed through the valley of Sturgeon Bay would allow the extension of the opposing barrier of the Niagara limestone farther toward the west, thus bringing into view lower formations (Clinton and Cincinnati); and the spur which excavated Eagle harbor, acted in the same way to permit the existence of the point just west from the harbor on which the Clinton limestone is again exposed.

Another evidence of the more southward tendency of the main glacier consists in the fact that it actually broke through the Niagara barrier in numerous instances in a southerly direction, but did not once encroach upon the Trenton, on the opposite side of Green Bay, although it hardly rises above the water level.

We may therefore regard the fact established that the local glacier which excavated the valley of Green Bay, as far south as to include lakes Winnebago and Horicon in Wisconsin, was deflected from its N. and S. course by the escarpment of the Niagara limestone; and we must infer that its greatest force was felt where it first encountered it. We see the escarpment most demolished between Port des Morts and Pt. de Tour, and conclude that that interval must lie in the course of the original glacier. A course nothward thence carries us up the valley of Little Bay de Noc and the Whitefish river to the shore of Lake Superior. If we examine the south shore of Lake Superior, we find that in a line directly north from the head of Little Bay de Noc occurs the only break in the otherwise continuous rock barrier. Dr. D. Houghton, in his report to the Michigan Legislature in 1840, says that "an elevated range of hills," or in another place, "an elevated and very regular chain of hills stretches from Point Iroquois to the Pictured Rocks," from which place they "pass away from the shore southwesterly," and Dr. Houghton adds that "the western prolongation of this rock has not been determined." From the mouth of the Chocolate river, six or eight miles east of Marquette, to a point one-and-a-half miles east of the mouth of Train river, the shore is low and occupied with drift deposits, the usual rocky barrier of sandstone is interrupted and entirely wanting. Both to the east and to the west from this interval the shore of the lake is formed by the rocky rampart either of the Lake Superior sandstone on the east, or of the Huronian and other Eozoic rocks on the west. Although this barrier passes a few miles away from the shore east of the Pictured Rocks it is nevertheless a continuous barrier of "sandstone hills" which cause the Falls of the Taquomenon, 90 feet in height, and appear in precipitous cliffs at or near Iroquois Point.

Again, from the mouth of Chocolate river to the falls of the upper Menominee occurs, in general, the strike of the Huronian, and from the latter place to the head of Keweenaw bay, a right line would pass some of the highest primary knobs and through the head waters of some of the principal rivers of the Upper Peninsula of Michigan. This rough and elevated character continues westward to the Montreal river, near the western extremity of Lake Superior. It is therefore rendered probable that the last lingering glacier, which was able to prolong itself beyond the south shore of Lake Superior, passed through the gap which occurs north from the head of Little Bay de Noc. It has been repeatedly stated by geologists who have observed the glacial striæ about Lake Superior, that their general direction is N.E. and S.W. It is therefore a fact of special significance, that the grooves at and near the mouth of Chocolate river show a north and south direction. At a point two miles west of the mouth of Carp river, and a few miles east of Marquette, there are two systems of glacial grooves, one running north 55° east, and the other north 5° east. Mr. Desor says of these: "The latter are distinctly seen crossing the others, and are therefore more recent. Some of them are besides distinctly curved, as if the body which produced them had been deflected in ascending the slope, a peculiarity not yet observed elsewhere." On an island east of Dead river (near Marquette) there are also two systems of furrows, one running N. and S. and one N. 20° E., the latter being the more distinct and sometimes taking the form of troughs four feet wide and two feet deep.* These indicate that the continental glacier moved in a direction N.E. and S.W., forming the deepest furrows, but that the local glacier passed N. and S. It was also, doubtless, "deflected" from its course, and the opposition of the Huronian formation, which gives the coast great elevation and abruptly turns it north from this place, may be supposed to have caused that change in direction.

In relation to the country between the head of Little Bay de Noc and the shore of Lake Superior we may infer that a valley exists, or did exist when the glacial epoch was waning, connecting Lake Superior with Lake Michigan through Little Bay de Noc, and that the present outlet of Lake Superior is of comparatively recent date. Not only do the descriptions of this tract by Messrs. Foster and Whitney confirm that inference, but examinations made the present summer, by Mr. A. S. Wadsworth of the Michigan Geological Survey, almost directly demonstrate the former outlet of Lake Superior to have been through the Whitefish valley. There is a continuous valley with high drift banks uninterrupted, from the mouth of the Whitefish river to Lake Superior. Upon reaching the water-shed which lies but little above Lake Superior and within twelve miles of the mouth of the Train river, the head waters of the two rivers interlock on an extensive flat and rocky bed from which the drift has been removed and piled up in continuous bluffs on either side. From the summit of these bluffs extend extensive "pine plains," toward the east and west. On this rocky bottom are traces of running water, spread over an area of many acres, consisting of the peculiar "pot holes," from which "many cords of rock" have been removed. There are also deep gorges and crevices worn smooth by the motion of water and drifting sand.

Thus it appears that not only was the outlet of Lake Superior through Little Bay de Noc up to the close of the Tertiary, but that it continued to exist there after the stratification of the drift. The curious excavation and piling up of the drift on either side of the Whitefish valley could only have been done since the deposit of the same, and the water-worn surface of the Trenton limestone, on the top of the water-shed, must have been produced since the dawn of the Terrace Epoch. The old Tertiary channel is still obscured by the drift, either to the east or west of the channel discovered by Mr. Wadsworth.

Ann Arbor, Mich., August 20, 1870.

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* Foster and Whitney's Report on L. Superior, Part I, p. 205.

Art. IV.—*Infusorial Circuit of Generations*; by Theod. C. Hilgard.

The soft and "naked," transparent and really animal[*] forms here to be considered, have some very striking and peculiar features in common. Their bodies are delicate, transparent, gelatinous, granular, and evidently *sexless*, although studded with reproductive yolks and locomotive molecules of the most varied description. On contact with air, when drying up, they do not leave behind any coherent coat or tissue whatever; but so soon as they are affected by incipient exsiccation, at once, by some sudden internal commotion, as if *melting* away, they become *liquid*, and entirely dissolve into a "sauce" of quite uniform, hyaline molecules, about $\frac{1}{2000}$′ line in diameter. They are all evidently *immature* forms, subject to a vast cycle of progressive and retrograde developments and infinitely multiplying the molecular germs at every individual dissolution.[†] A little salt, glycerine, or sugar destroys their present form; but they seem to be hardly affected by morphia or atropia, even in strong solutions.

It is this feature of the *non-endurance in drying up*, which renders it at once certain, that no such sarcode bodies can continue to exist *in integro*, when exposed to the full heat of summer, on a cracking dry tub, or on a roof, likewise as torrid as a blazing July sun can render it within four weeks. The same applies to all the confervaceous, palmellaceous, protococcous, desmidiaceous, etc., fresh-water spawns, of true Mosses; which, once collapsed by drought, rarely continue growth in a progressive sense. With the exception of their *common* "nostoc"-phase[‡] (specially adapted to endure even excessive dryness) they

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[*] i. e. exclusive of all the chlorophyll-endowed, silica-coated, and automatous, or cellular cell-like sarcodic bodies and also the clear and vibrionic forms which belong to the algoid *bryaceous developments*. They are partly classed as green "Infusoria," and also constitute the "Chlorospermeæ" of "Algæ."

[†] The same doubtless applies to a small "Stentor Roe," seen hovering up and down in water taken from ponds, aquaria, etc. It is of a hazy white color, scarcely perceptible to the naked eye, and remarkable for never touching the surface. When placed under the microscope, in a drop exposed to air, this animal germ (in shape resembling a Cyprea or a coffee bean) is seen violently throwing open its "cloak" or mantle, exhibiting an intense ciliary (*fingered*) vibratory action, *all over the interior surface*. It then throws out hyaline constitutive brood-balls of various sizes, *each endowed with the same "fingered" action*—(as if "kneaded about" in invisible hands)—and ultimately entirely *flows apart into such fleshy cilia*, only leaving the *intestine* behind.

[‡] This form of self-multiplying, serial chorophyll bead-strings enveloped in a foliaceous slime is common to Lichens (particularly the genus Collema) and various brooding-phases of the algoid (*chlorospermous*) moss-spawns. With the Lichens, the internal chlorophyll of their thallus often develops, as is well known, in similar bead-strings, borne on the end of colorless (fungoid) tissue-fibers; in a manner also represented in the anatomy of *Blodgettia confervoides*, in Harvey's "Nereïs."

"revive" *only* by starting anew from very reduced, but immensely multitudinous *constituent particles of their own*, which perdure exsiccation. In the class of Fungi we meet with similar examples, as e. g. in the case of the yeast-plant, which can endure a considerable degree of exsiccation without impairing the vitality of those cell-*contents*, which actually exercise the fermentive energies and also consume the old cell-coat—(*not* common cellulose, by the way) in this process of reviving. Likewise, the vermillion, gummose (*tubercularia*) pimples on rotting Black Oak branches can endure a baking process in the burning sun, but still revive on contact with water. Its spicular "spermatia" (*fusidium*, resembling Naviculæ or magnetic needles) at once assume an oscillatory motion and swell up to the size of those didymous (*trichothecium*) spores which presently stand erect on pedicels, as a pink velvet, in the chinks of the bark and collapse at the first touch of the sun; while their ultimate subcortical development into a mature, "black enamel" Sphæria again perdures in the heat.

Under the circumstances above mentioned, the rain water and dry dust carried by the wind to the roof, and thence collected into a perfectly dry tub, itself standing on a similar roof, within a few days was found swarming with all the minor phases of the Vorticello-planarian germ-developments. Both the bodies and the yolks or gemmæ of the latter occasionally become reduced, by spontaneous dissolution, into very minute particles, each in the *wet* state capable of resuming the regeneration of individual germs. Judging from analogy, it is but reasonable to suppose, that it is this reduced nubecular and molecular condition, which adapts them to last and survive in a *dry* condition, as we find it not only with the Fungi, but also in the case of the pruinose-pulverulent, primitive moss-spawns, all three agreeing in this feature of being "reduced to dust," out of which they are again resuscitated. This evanescent condition, however, where gelatinous particles of about $\frac{1}{3000}$ of a line diameter shrink alike to imperceptible dimensions, affords no pretext whatever for assuming identities, just because we ourselves lose the *means of discrimination*. Whenever the identity of *substance* is preserved, each of these various molecular organisms preserves its cyclar developments distinct from similar, corresponding ones as true species, so far as my observations go.

There being, at present, no comprehensive pictorial works available to fall back upon for reference, that are sufficiently correct, even in their designs, to identify the forms, allowance must be made for the liberties of comparison taken in the following descriptive representation of the most frequent infusorial processes.

On extensive clay formations, all over the central part of the Mississippi valley, the first appearance, in the warm season, of vegetable life, e. g. in water-pools recently formed by rain, etc., is mainly that of "Chlamydococcus pluvialis," even where the clay is immediately taken from the deepest excavations. As the sequel of my papers will show, this particular form belongs to the common Silver-moss (*Bryum argenteum*) which is widely disseminated all over the surface of the globe, and that, by the way, rather scantily "fructifies" in a "sexual" fashion, i. e. by the development of a *theca;* but on clayey soils fills all the sluggish and stagnant waters with its virescent uliginous spawns; while it covers the surface of fields, by millions of acres, with a minute crust, or "*brick red leprosy,*"* whose fine, molecular dust is swept aloft by every wind. Immediately before the frost, the same fields are densely covered with a small crop of minute moss, doomed to perish in this form, but revived in its spawns at the first thaw in the shape of a universal *chalk-white* "*clay-bloom,*" or pruinose efflorescence from the soil, and that in water at once re-develops into the so-called *Protococcus* (or *Chlamydococcus*) *pluvialis* in the form of green flagellate-roving beads.

These minute, but in this instance *coated*, swarming cells are replete with chlorophyll, and are globular ovoid in shape. They have at their smaller end, just where the motor *flagellum* (or vibratory lash) arises, a clear point of substance; wherein, in a small percentage of these cells, *a parasite* is found to develop.

This parasite is a perfectly colorless globule, apparent in the clear navel-point of the cell, and exhibits a faintly opalescent hue. As it grows, the cell which harbors the "*incubus*" loses its own individual vitality. It ceases to swarm about and dissect into living, chlorophylliferous and automatous progenies, as the live ones do. Instead of spontaneously dissolving as in the living process the cell-coat remains firm; and as the parasitic animal yolk grows and occupies more space, executing tremulous and vibratory contractions, the chlorophyll is pressed into the rear, a lifeless mass. At last the cell is ruptured in front, and the cupular-compressed, dead, chlorophylline mass remains inert and void of life until devoured by Infusoria or the zymotic fungus. The cell-coat, likewise, is effete, while the large globular and somewhat acicularly-granulated incubus, after a few very wry contractions, at once widely opens a large, ciliate mouth, gaping across the sphere's surface; and disengaging or displaying a girdle of cilia round the rear part of the body, it immediately represents the *free-roving Vorticella* in full equipment.

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* See St. Louis Med. Reporter, Jan. 1st, 1867, pp. 522, 527—528. Also Proc. St. Louis Ac. Sc. (July, 1861), vol. ii, No. 1, p. 160; and vol. i, p. 156. For "Chlorococcum" read "*Sphærocarpus*" (lately renamed "*Protuberans*" Ag.) and its "botrydium" progenies. The latter collapse and turn red. This pulverulent, *miniate* "*Lepraria kermesina*" Auct., must, however, by no means be confounded with the darkly purpureous, uliginous moss-spawns which cover, e. g. the hilly "Orange-sand" regions of the State of Mississippi. It is prevalent in winter in damp weather, and consists of matted red "Microcoleus" or lumbricoid (sheathing) moss-cells, each one containing a central brood-fiber which is medullary-dotted, dissecting, and fascicularly surrounded by a stratum of (automatous, prorepent) "Oscillaria"-fibrils. Not only the ultimately enlarged (chlorophylliferous) brood-segments, but also the dark undulating fiber, form brood-balls (terminally). Its gelatine forms a cement of the loose sandy clay, and a home or abode for the Cladoniae (or bright-green foliolate lichens) as well as for grasses, etc.

Its subsequent "encystment," into a spherical cyst *densely covered with short prickles* (somewhat like the rim of a Heliopelta) and containing entrail-like designs, is well known.* Also, that it eventually bursts—*occasionally*, at least—and disgorges a peculiar sort of *wafer*-shaped, elliptical (not ellipsoidal!) cells, or nuclei, whose ulterior fate and abode, however, hitherto remained unknown.

The fact is, that they rise to the *surface*, where, on account of their shape, they *inhere*, as an almost imperceptible pellicle or stratum, which to the microscopic observer is the instantaneous index of the precise *focality* of the surface.

In this state, when no food is supplied, they long remain unaltered. When meat, bread or other nutritive matter is added, however, they *develop* (particularly where the absence of light prevents the confervaceous or green, chlorophylline growths from becoming paramount) into the smallest *Vorticellæ*. The center of the wafer-shaped disc, inherent in the denser surface of the water, protrudes downward into a little clear knoll or navel, which soon begins to *jerk*, representing as it were a pinhead of $\frac{1}{1000}$ line diameter on a little thread or coiled stalk; and, as the whole increases in size, it now constitutes the well-known *spirally pedunculate* Vorticella; pyriform-bell shaped, somewhat pitcher-mouthed, with cilia around the orifice and a clear granular *nucleus* or "germinal speck" inside.

The multiplication of the pedunculate Vorticellæ, by fission, lengthwise, and by budding-out, sideways, at the rear end, is sufficiently known. As the bud tears loose, there is yet no oral aperture visible. There is, however, a girdle of cilia at the *rear*, wherewith it performs an undulatory vibration, until it tears loose by spinning round; and after irregularly prancing about, and rebounding at head-long speed, within a few minutes it "settles" upon some suitable surface, with the ciliated rear end; and spinning out a *podetium*, or peduncle, often within a quarter of an hour, the rear cilia get applied downward to the body and disappear; while after a little time a fully ciliated mouth now opens *in front*.

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* In fig. 215, Carp. "Micr." (p. 446), the short prickles are omitted, B. to E.

As for its *retrograde* multiplications, when a Vorticella gets "sick," for want of air or food (as when kept between glass-plates held apart and glued round about, or cemented, to prevent evaporation), the body contracts to a perfect globe, with a big germinal point, "eye" or nucleus in the middle; the throat contracted, and the lifeless cilia standing around like the limb of a rose-calyx. The germinal speck, ogle or nucleus soon becomes immensely bloated, protruding out of the crown or ciliate aperture like a dim, hazy *balloon*, and then being either suddenly or gradually exploded, its almost invisible granular contents settle around and increase into a rather densely *punctuated cloud*, run up like a *cumulus;* its tips mostly warty as with (dotted) strawberries, a sort of primordial "framboësia." It is to this form that I wish to call particular attention, since it presents *the most minute phase of individual animate life* visible at represent under the known powers of the microscope: being the ultimate retrograde development-phase, as well as the first manifestation, common to all such soft primitive *sarcode* bodies, from the "Vorticellan" to the most bulky "Paramecian" forms. And from each little dot in these "clouds of life" a separate Vorticella can be seen to develop! It is here, indeed, at this first *visible* advent or exordium of animate life, and the resurrection of millions of germs through the spontaneous dissolution of a single one, that the last nubecular *microscopic* perceptions closely resemble the last nebular telescopic as well as the *theoretic* ones of Laplace's cosmogony.

For the present let us call such often repeated forms of retrograde self-dissolution and self-multiplication a germinal *nubecula*. Such likewise occur in a very closely analogous form in the self-maceration (of the engulfed pencil-beads and the enlarged "oidium"-joints) of the yeast or "zymotic" fungus. The difference being, that in the case of *animal* infusoria the dots remain affixed, and, after jerking apart, rapidly travel on separately with a vaccillating motion resulting from their warped surface (*true* Zooglœa Termo *Cohn; not* that of *Klob*), while in the case of the mucous or polypoid fungine diffluence (erroneously called by the above name by *Klob*), the component blunt-cylindrical Cacteria are not mutually fixed, but all simultaneously slowly move onward and apart in slimy *trails*, without a perceptible rotation, simply quivering, and ultimately enlarge into fibers. Of the *black* or "indissoluble" nebula-form of the zymotic or yeast-fungus I have already treated in the St. Louis Medical Reporter, Jan. 1st, 1868, (Zymotic Condition, etc.) and Proc. A. A. A. S., 1870, *et ante.* Neither the animal molecules nor the (coated) "Cacteria" join into file, as do the fermentic sarcode-vibrios, being *naked.*

The watchful observer will have opportunity of witnessing another sort of "fertile dissolution," of the more bulky Vorticellæ, by the discharge of certain globular, granular "pellets," surrounded with other adhering and *jerking* particles—(probably the "acineta" of some authors)—while containing the "currant-shaped" yolks,—hereafter to be described, together with its "amœba" or pseudopodial dissolution, when treating of the so-called "*Paramecium Aurelia.*"

[To be continued.]

ART. V.—*On the application of Photography to the determination of Astronomical data;* by ASAPH HALL.*

ANY one who has witnessed a total eclipse of the sun must have felt his utter inability to make a correct description of the various features of the phenomenon, and must have wished for some means by which all these features, so suddenly and so grandly displayed, might be portrayed impartially and truthfully and in such a way that they could be subjected to a cool and leisurely examination. Such a means is furnished in a good degree by photography. A few photographs of the corona and protuberances of a total eclipse are far more trustworthy than all the hand sketches that have ever been made. It is true indeed that by the union of several observers and each one giving his attention to some specific point much may be learned, and some things perhaps that photography is not yet able to exhibit, but speaking generally we may say that photography combines the powers of all these observers and furnishes a record admirable for its truthfulness. Photography combines the powers of all these observers and furnishes a record admirable for its truthfulness. The beautiful photographs of the solar eclipse of Aug. 1869 obtained by Prof. Morton and Dr. Curtis, and those of the eclipse of 1870 by the English and American parties in Spain and Sicily attest the truth of this assertion; and the photographs of the moon by Messrs. Draper, Rutherfurd and De la Rue also give ample evidence of the value of photography when applied to descriptive astronomy. But that photography gives us the means for the exact measurement of angles and distances and thus of determining accurate astronomical data in the case of a solar eclipse or of a transit of a planet does not yet appear to be clearly established. In the hope of provoking discussion and investigation of the subject a brief review of what has been done in this application of the photographic method seems opportune, especially so, considering the extensive use that may be made of the method in observing the transit of Venus now near at hand.

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* Read before the Washington Philosophical Society.

The first photographs of double stars, made for the purpose of determining by micrometric measurement their relative angle of position and distance, were those of Mizar and its companion, made at the Harvard College Observatory in April and May, 1857, by Messrs. Whipple and Black of Boston. Professor G. P. Bond has given in the Astronomische Nachrichten, No. 1105, the results of his measurements of the thirteen photographic images. The zero of the angle of position was found by moving the telescope in right ascension after an impression had been taken and taking a second one on the same plate. This process repeated gave a series of photographic images on the same plate and the right line passing through the series gave the direction of the daily motion of the heavens. The probable error of a single measurement of the photographic distance of the images was found to be ± 0·″12, or somewhat smaller than that of a direct measurement with the common filar micrometer. During the summer of 1857 many more photographs of this double star were taken, and in the journal above mentioned, No. 1129, Prof. Bond has given an elaborate account of the measurement of sixty-two photographic images. For this measurement of these images a new and improved micrometer was employed, consisting of an achromatic microscope with a magnifying power of 2200. Under this microscope the star images appeared as aggregations of minute drops of matter and looked like the result of a great number of vibrating and momentary impressions. They were generally symmetrical with a gradual condensation toward the center of the image, and the bisection of an image with the wire of the micrometer could be done with great exactness. The probable error of the center of an image was found to be ±0·″051, and hence that of the distance of two such centers to be ±0·″072. Adopting the estimate of Struve, ±0·″127, as the probable error of a single measurement of a double star of this class with a filar micrometer, the measurement of the photographic images would have a relative value three times greater, or $= \left(\frac{0\cdot127}{0\cdot072}\right)$. The accuracy of the measurement is better shown by the numerical results obtained by Prof. Bond, which are as follows:

Mean Exposure.	Distance.	No. of images.
13ˢ	14″·31 ± 0·034	7
16	14 ·19 ± 0·035	7
18	14 ·18 ± 0·033	8
24	14 ·23 ± 0·035	8
25	14 ·15 ± 0·034	7
30	14 ·28 ± 0·034	7
33	14 ·19 ± 0·033	8
36	14 ·20 ± 0·032	10
24·5	14 ·21 ± 0·013	62

The application by Prof. Bond of photography to stellar astronomy was confined to stars brighter than the seventh magnitude, and with the hope probably of finding some encouragement of obtaining photographs of much fainter stars, he has discussed very fully in the Astronomische Nachrichten, No. 1158 and 1159, the effect of increasing the times of exposure of the photographic plates. The result which he arrives at is that "deficiency of light can be more than compensated for by a proportionate increase in the time of exposure;" and concludes that an exposure of ten minutes with the Cambridge Equatorial would give a photographic image of a star of the ninth magnitude. This, however, appears to be a question that can be decided only by actual experiment.

The last essay referred to closes Prof. Bond's work in stellar photography. He intended to resume the subject and was confident of being able to make photographic images of stars down to the ninth magnitude, but failing health and a desire to finish his work on the great nebula in Orion prevented him from undertaking any further experiments. Having participated in the work of measuring the photographic images and in reducing the measurements, and having a vivid remembrance of the labor performed, I take the liberty of stating my own estimate of the two methods of observing double stars, viz: the photographic method and that of direct measurement with a filar micrometer or heliometer. In the case of double and triple stars I have no doubt that the better method is that of direct measurement. The labor of setting the circles and finding the star is common to both methods, but during the time required to adjust properly the clock work and make a series of photographic images a practised observer would make and reduce a series of direct measurements. It is thus possible by the direct method more. easily to repeat the observation under varied conditions of atmosphere, observer and instrument, and in this way to render the final result less liable to systematic errors. It is true that according to Prof. Bond's calculations, the photographic method is decidedly the more accurate, but some experience makes one, I think, distrustful of inferences drawn from the values of probable errors. The most dangerous errors of observation are those that are constant or systematic, and these the theory of probability does not and can not recognize. It is this class of errors which is the source of the large discordances frequently seen in different determinations of the same quantity while each single determination has apparently a very small probable error. It should therefore be the care of the observer to vary the circumstances of his observation in order to avoid systematic error, or to give it as much as possible the nature of those irregular errors which in the long run tend to eliminate themselves. Finally, it may be stated as a general rule that, other things being equal, the simpler and more direct the method of observing, the better. In order to justify the interposition of any new process it must be shown that this process gives greater accuracy or greater rapidity of observing or both. Thus the chronographic method of observing transits is justified on the ground that it gives greater ease and rapidity of observing, since the gain in accuracy is scarcely sensible.

In the case of groups of stars like the Pleiades or Præsepe there would be a great advantage in using the photographic method provided the plates could be made sufficiently sensitive, so that images of stars of the ninth and tenth magnitudes could be obtained. Mr. Rutherfurd, who has done so much in astronomical photography, has made photographs of both the groups mentioned, and from his plates Dr. B. A. Gould has deduced positions of the stars. Dr. Gould's memoir on the Pleiades was presented to the National Academy five years ago, and it is to be regretted that it is not yet published.

The first application of photography to determine the times of contact in a solar eclipse was made by Mr. Warren De la Rue in the case of the eclipse of July, 1860. In the Philosophical Transactions, of the Royal Society of London, 1862, Mr. De la Rue has given a full account of his work, together with an engraving and description of the micrometer employed for measuring the photographs. The Kew heliograph was used in obtaining the photographs, an instrument designed by Mr. De la Rue for the purpose of making photographs of the Sun's disk. By means of a Huyghenian eye-piece the image of the sun was enlarged to a diameter of nearly four inches. Two position wires at right angles to each other were placed in the focus of the eye-piece at an angle of nearly 45° to a parallel of declination, and the final correction to the position of these wires was found by observing transits of the sun's limbs after the method proposed by Mr. Carrington. The wires being photographed on the plates their images furnished a means of finding the zero of position, and the plates were measured for the position angles of the cusps and their chords, also the radii of the sun and moon and the positions of their centers. By comparing the interval of time of two consecutive photographs with the measured position of the centers, the relative motion of the sun and moon was deduced and hence the times of contact which agree tolerably well with each other, but not so well perhaps as those of the ordinary direct observation. The value in arc of a single division of the measuring scale was found by measuring on the plates the radius of the sun in parts of the scale and then assuming a value of the sun's radius. A very doubtful correction of $-4''\!.1$ is deduced for the sum of the semidiameters of the sun and moon.

Mr. De la Rue speaks of having made some observations to determine whether in the process of drying the images had undergone any distortion, and says: "The result, however, proved that there was no appreciable contraction, except in thickness, and that the collodion film did not become distorted, provided the rims of the glass plates had been well ground." This point being a fundamental one appears worthy of further investigation. There is some uncertainty and vagueness about Mr. De la Rue's methods which do not give much confidence in the accuracy of his results, but on the whole he appears to have shown that the photographic method promises good results which is all perhaps that a first trial could be expected to do.

The next and last memoir published on this subject is that by Messrs. De la Rue, Balfour Stewart and Benjamin Loewy, on Solar Physics, Philosophical Transactions, 1869, giving an account of the positions and areas of the sun-spots observed with the Kew photoheliograph during the years 1862 and 1863. In order to determine the heliographical latitude and longitude of a spot two elements are required, viz: its angle of position and its distance from the sun's center at the time of observation. These elements were obtained by measuring the photographic plates, the position wires being similar to those used by Mr. De la Rue in the solar eclipse of 1860, and their zero being determined in the same manner. This memoir contains a large amount of interesting information concerning the position and areas of the solar spots, but the determinations of position are vitiated in some degree by the optical distortion of the instrument. The observers at Kew have made experiments to determine the amount of distortion, but no definitive result has yet been reached. They say that the following facts may be regarded as established: "1st, that the image of any object photographically depicted is liable to a distortion, which varies at different distances from the center of the field, and the amount of which may be determined for every instrument by methods similar to that employed by ourselves; 2d, that in our case the image of an object is larger when formed near the edge of the field than at the center, and that the amount of elongation of a unit of length at the center increases with its distance from the center." Their conclusion is that the inquiry is not sufficiently far advanced to justify any corrections of the positions of the spots on account of the effect of distortion, but they express the hope that at last they will be able to give thoroughly satisfactory constants for the effect of displacement in their instrument.

The photographs of the solar eclipse of August, 1869, have not yet been measured and discussed so far as I know, but it is pretty certain that all the images are affected by distortion which will in a measure render the results dependent and untrustworthy. It is to be hoped, however, that these photographic plates will be subjected to a careful examination in order that some estimate may be made of the extent of error to which they are liable. In the case of a solar eclipse, or of a transit of a planet over the sun's disk the photographic method has very great advantages over the observations of contact in many respects, and the errors to which it is subject are worthy of the most thorough investigation. The observation of a contact is uncertain on account of irradiation, and it is momentary also, so that if lost by a cloud, or in any way, the observer is compelled to view for several hours the phenomenon without being able to observe it. On the other hand when the sky is clear a photographic image can be obtained in an instant, and even if all the contacts be lost, valuable results might be secured if the readings of the photographic plates can be correctly reduced. Just here then is the point for experiment, investigation and invention, since it is most desirable that no doubt should remain as to the possibility of correctly measuring and reducing the photographic observations of the transit of Venus.

Mar. 25, 1871.

ART. VI.—*On Ralstonite, a new Fluoride from Arksut-Fiord;* by GEO. J. BRUSH.

THE recent exploitation of the Greenland cryolite has not only led to the discovery of crystallized cryolite, but has given to mineralogical science several new fluorides, two of which, thomsenolite and pachnolite, are found in beautiful crystallized forms.

I now call attention to another fluoride observed, a few months since, by Rev. J. Grier Ralston of Norristown, Pa. Mr. Ralston found a mineral in minute octahedrons associated with thomsenolite, and being unable to identify it, he sent it to Prof. Dana, by whom the specimens were passed over to me for examination.

The crystals of the new mineral are octahedral; and in some cases they are very minute, but occasionally one to one-and-a-half millimeters in diameter. They are often implanted on the thomsenolite crystals, and also apparently intercrystallized with this species, making it extremely difficult to separate the new mineral sufficiently pure for analysis. The planes of the octahedron are often tinged slightly yellow, and many of them are dull and iridiscent, owing to an excessively thin film of oxide of iron, and hence exact measurement of the inclinations of the faces cannot be made. But they appear to be symmetrical with equilateral faces, and, in some cases, have all the solid angles replaced by a minute plane. With so regular a habit and the planes alike in lustre I cannot doubt that they are isometric octahedrons, and hence that the small plane on the angles is a cubic plane.

The mineral is colorless to white, with a vitreous luster, and has a hardness greater than fluorite, equal to about 4·5. Specific gravity, taken on 25 milligrams, gave 2·4.

In the closed tube the mineral whitens, yields water at first, then gives off fumes and a copious white sublimate, while the walls of the tube are etched. The vapor in the tube, as well as the water, reacts acid. Even at a very elevated temperature the heated fragment retains its original form and does not fuse. In the open tube the mineral gave similar reactions.

B.B. on charcoal a faint white sublimate was observed. In the platinum forceps the mineral whitens without fusion and colors the flame a soda-yellow; moistened with sulphuric acid this coloration was unchanged. Heated with cobalt solution in the platinum forceps the mineral assumed a bright alumina-blue. In salt of phosphorus the substance was readily dissolved, giving a colorless bead in both O. and R.F. In a soda bead it dissolved with effervescence.

The mineral was found on close examination with a magnifier to be so intimately associated with thomsenolite, that it was deemed impracticable to separate a sufficient quantity for any thing more than a preliminary qualitative examination in the wet way. A small portion, some 30 milligrams, selected with great care to ensure purity, was, decomposed in a platinum capsule by sulphuric acid. It gave off fluohydric acid, etching a glass plate, and on solution it gave with reagents a precipitate of alumina, with evidences of the presence of lime and soda. With the spectroscope, the pure mineral alone gave only the soda line, but when even a very minute speck of thomsenolite was associated with it, the lime line was very marked. The solution from which alumina was separated afforded on evaporation to dryness a minute residue, which, when examined with the spectroscope, gave both soda and lime lines.

It therefore appears that the mineral under examination is essentially a hydrous fluoride of aluminum with probably a small amount of calcium and sodium. Its isometric form, and its infusibility, distinguishes it from all other fluorides yet described as occurring at the cryolite locality in Greenland.

The only mineral which in general chemical characters approaches it is the fluellite from Stenna-Gwyn in Cornwall. This rare mineral, according to Wollaston, is a fluoride of aluminum, but it occurs in elongated orthorhombic octahedrons. These facts are, I think, sufficient to warrant the conclusion that the Greenland octahedral mineral is a new fluoride, and I propose for it the name *Ralstonite*, after its discoverer.

ART. VII.—*Notes on the Primordial Rocks in the vicinity of Troy, N. Y.*; by S. W. FORD.

IN view of the prevailing uncertainty respecting the age of the rocks of that portion of the Taconic series of Professor Emmons lying east of the Hudson river, I was led several years ago to undertake the investigation of some of these rocks in my own neighborhood, though I had but few hopes of learning anything essentially new about them. It soon became apparent that much valuable information might be obtained from them; and from certain facts which early came under my observation I was induced to continue their study. I propose here to notice briefly some of the more noteworthy results thus far obtained.

The rocks immediately east of the Hudson at Troy are fine black, glazed shales, with occasional sandy layers, and have usually been regarded as belonging to the Hudson River formation. They have been greatly crushed, but their general dip is evidently eastward, and at a high angle. They extend eastward about half a mile, and form a hill of considerable magnitude within the city limits. Following the course of this hill northward, we find them frequently well exposed in railway cuttings, and before reaching Lansingburgh, which is three miles distant, in a bold elevation several hundred feet in height.

The only fossils which these shales have afforded, are the obscure form described under the name of *Discophylum peltatum* (Pal. N. Y., vol. i, p. 277, plate lxxv, fig. 3), and two or three species of graptolites, the latter having been but recently obtained. The graptolites resemble closely certain well known Hudson river forms, but whether certainly identical I am at present unable to state. If truly Hudson river shales, then the absence of any other fossils in these rocks except those above mentioned appears not a little remarkable.

Upon the east, after an interval of concealment varying somewhat in different localities, these shales are followed by the widely different rocks of the "Taconic" series likewise dipping eastward, and apparently at about the same angle. The best exposures of these rocks in this vicinity occur opposite the central portion of the city, where they are brought to view in a number of abrupt, quickly concealed outcrops. These outcrops trend northerly and southerly, and appear to be all constructed upon the same pattern, having on the west a steep, on the east a more gradual slope. Only the western faces are naturally exposed. This uniformity of structure is very striking, and there are reasons for believing that it has resulted largely from successive short, sharp folds in the strata, of which we have a fine example in the rocks east of Lansingburgh; but as nearly the whole district is covered with a thick sheet of drift, and the rocks bear evidence of extensive faulting, much further study will be necessary before it will be fully understood.

These outcrops generally consist for the most part of coarse red and yellow weathering slates and shales, with occasional thin-bedded sandstones; but the most of them are supposed, and four of them are known, to hold subordinate limestone deposits. Of these deposits the two western-most individually consist of a few courses of thick-bedded limestone, and of irregular, sometimes lenticular, sparry and frequently pebbly masses, varying from one to several hundred pounds in weight, imbedded in a coarse, dirty-looking arenaceous matrix; while the others form tolerably compact, even-bedded limestones, with an abundance of scattered black nodules, from twenty-five to thirty feet in thickness.

So far as investigated, these limestones have been found to be highly fossiliferous, though the fossils are usually in a very fragmentary condition. From two of them—one of the conglomerates and one of the even-bedded masses—the writer has made frequent collections during the last three years. With a single exception the same species occur in both. Up to the present time they have yielded eighteen species, which are distributed as follows:

Protozoa (*Archæocyathus*)	1	species.
Brachiopoda	7	"
Lamellibranchiata	1	"
Gasteropoda	1	"
Pteropoda (*Hyolithes*)	2	"
Annelida (*Salterella*)	1	"
Crustacea	5	"
Total,	18	"

Of these, six—*Obolella* (*Avicula?*) *desquamata* (Hall), *O.* (*Orbicula?*) *crassa* (H.), *O.* (*Orbicula*) *cælata* (H.), *Metoptomas rugosa* (H.), *Theca triangularis* (H.), and *Agnostus lobatus* (H.)—were figured and described in the first volume of the Paleontology of New York in 1843, from this locality; and two—*Conocephalus* (*Atops*) *trilineatus* (Emm.) and *Olenellus* (*Olenus*) *asaphoides* (H.), from Greenwich, Washington county. All the rest are new or undescribed.*

Desiring further information in regard to certain of these new species, I several months since wrote Mr. E. Billings, Paleontologist of the Geological Survey of Canada, at the same time giving him a list of the species in my possession from this quarter. In reply Mr. B. informed me that he was just then engaged upon a collection of new fossils from the Lower Potsdam formation below Quebec, which he strongly suspected to be identical with my own: and on comparison it was found that fifteen out of the eighteen species from Troy were held by us in common, and shown to be perfectly identical. Such an unlooked for result of course surprised us greatly. That the Lower Potsdam formation below Quebec, and the western portion of the Taconic series near Troy* are of the same age, there seems now but little room for doubt.

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* Unless one of them should prove identical with the species of *Cypricardia* figured by Emmons (American Geology, p. 113, plate 1, fig. 1.)

Two very characteristic fossils of this formation are the opercula of two species of *Hyolithes*, upon which I communicated a note in the preceding number of this Journal. One of them was there described as a "minute, circular species, with four pairs of lateral muscular impressions and two smaller, dorsal, all radiating from a point near one side;" the other as "larger, and like a *Discina* on the outside." The former occurs quite abundantly in the Troy limestones, and is a very beautiful little object. It varies in size from a mere point to a diameter of three lines. Perfect specimens have a rich, polished appearance. The other occurs more rarely. As might naturally be expected, these rocks contain immense numbers of *Hyolithes*. Indeed, large portions of the limestone are often almost wholly composed of them.

Without doubt this formation in New York will yet afford many new species. The even-bedded limestones east of Troy, to which especial attention has been given, as well as portions of the conglomerates, are literally loaded with fossils, and promise richly to repay investigation for a long time to come. Their associated slates, shales and sandstones have as yet afforded no fossils. Near Lansingburgh, however, where what is at present regarded as a lower member of the formation, consisting of heavy and thin-bedded gray sandstones with interstratified black slates, is exposed, a few obscure Fucoids have been found, but these rocks have been but imperfectly investigated. Neither the thickness nor precise eastern limit of this formation has yet been ascertained.

Troy, N. Y., May 24, 1871.

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* These rocks have hitherto been referred, though with some doubt, to the Calciferous portion of the Quebec Group; but all modern investigations in our older strata have steadily pointed to their higher antiquity; and it is simply justice to state that, by several geologists besides those who have adopted Prof. Emmons' views of their age, this has long been suspected.

ART. VIII.—*Notice of some new Fossil Mammals from the Tertiary Formation;* by Professor O. C. MARSH of Yale College.

IN association with the Reptilian fossils collected by the Yale College party last summer, and already described in this Journal,* numerous remains of Mammals were also discovered, and in the following article some of the more interesting new species are briefly characterized. A few species from the other Tertiary lake-basins of the Rocky Mountains have been included, as they throw considerable light on the ancient sub-tropical fauna of that region. The present notice is merely preliminary to a full description, with illustrations, now in course of preparation.

Titanotherium ? anceps, sp. nov.

The largest extinct mammal discovered by our party in the Green River basin was apparently one of the rarest; and the remains obtained, although in themselves characteristic, include, unfortunately, none of the teeth sufficiently well preserved to afford generic characters. The single species thus indicated has accordingly been referred, with a doubt, to the genus *Titanotherium*, seemingly a near ally, until the discovery of additional material clears up the question of its exact affinities.

The specimens discovered, which evidently pertained to three different individuals, mainly consist of several dorsal vertebræ, the distal end of a humerus, the greater portion of a tibia, and some of the smaller bones of the extremities. They indicate a Pachyderm, much larger than any other known mammal from the same deposits, and about two thirds the size of *Titanotherium Prouti*, from the Tertiary basin east of the Rocky Mountains. The anterior dorsal vertebræ preserved have both articular faces slightly concave, thus distinguishing the species at once from *T. Prouti*, which has in this part of the series the front vertebral face very convex, and the posterior face concave. Another marked difference is seen in the tibia, which at its proximal end has the femoral articular surfaces contiguous, with no prominent elevation between them, resembling in this respect some of the Proboscidea.

Measurements.

Length of anterior dorsal vertebra, on lower surface,	2	inches	2	lines.
Width of posterior face between rib cavities,	3	"		
Height of posterior face,	2	"	5	"
Transverse diameter of tibia at proximal end,	4	"	10	"
Fore and aft diameter,	4	"	3	"
Transverse diameter at distal end,	3	"	11	"
Fore and aft diameter,	3	"	3	"

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* Vol. i, 1871, pp. 192, 322, and 447.

The remains were found by Lieut. Wann, and the writer, in the "Mauvaises Terres" deposits, near Sage Creek, Western Wyoming. The geological horizon is lower Miocene, or perhaps Eocene.

Palæosyops minor, sp. nov.

This species is indicated by a molar tooth, from the right lower jaw, and probably by some other less characteristic remains. The tooth, which is apparently from near the middle of the series, is of the *Palæotherium* type, and nearly resembles in its main characters the corresponding molar of *Palæosyops.* The crown is composed of two united, antero-posterior lobes, with crescent-shaped summits. The anterior lobe is the more elevated, and the posterior has a greater fore and aft extent. The animal thus represented was apparently about as large as the South American Tapir, and less than one half the size of *Palæosyops paludosus* Leidy,* from the same deposits.

Measurements.

Antero-posterior diameter of lower molar,	10	lines.
Transverse diameter of front lobe, at summit,	5·	"
Transverse diameter of posterior lobe, at summit,	5·6	"

The only known specimens of this species were found by the writer at Grizzly Buttes, near Fort Bridger, Wyoming, in the same deposits as the preceding species.

Lophiodon Bairdianus, sp. nov.

The remains on which this species is based consist of portions of several skeletons, with numerous teeth which show considerable variation in size and other characters of minor importance. The various specimens indicate an animal somewhat smaller than the modern Tapir of South America, but much larger than the *Lophiodon modestus*,† founded by Dr. Leidy on a tooth from the same Tertiary beds that afforded the fossils under consideration. From the latter species, so far as it is now known, the present specimens may be readily distinguished, moreover, by the enamel of the teeth, which, instead of being coarsely wrinkled, is nearly smooth, or marked by very delicate, irregular striæ.

Measurements.

Length of portion of upper jaw, enclosing the three posrior molars,	25·	lines.
Antero-posterior diameter of last upper molar,	9·	"
Transverse diameter of same,	10·25	"
Length of fragment of lower jaw with three posterior molars,	25·	"

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* Proceedings Philadelphia Academy of Natural Sciences, 1870, p. 113.

† Proceedings Philadelphia Academy of Natural Sciences, 1870, p. 109.

The specimens now representing this species, which is one of the most common fossil mammals in the earlier Tertiary of Western Wyoming, were found by G. B. Grinnell, J. W. Griswold, C. W. Betts, A. H. Ewing, J. M. Russell, and the writer, at various localities near Fort Bridger, and on the White River, in Eastern Utah. The species is named in honor of Professor S. F. Baird, of the Smithsonian Institution.

Lophiodon affinis, sp. nov.

A second and somewhat smaller species of the same genus, closely allied to the preceding, is indicated by various fragmentary remains, including several molar teeth in an excellent state of preservation. A comparison of the last upper molar with that of *L. Bairdianus*, shows, aside from the smaller size, a marked difference, especially in the contour of the crown, which has a deep notch in the outer posterior margin of the base, between the external tubercles in which the transverse ridges terminate. In the species just described, the margin is here nearly straight. The present specimen, moreover, has the small anterior external tubercle more prominent, and less closely connected with the adjoining ridge. This tooth is larger than the corresponding one of *Lophiodon modestus*, and has quite different proportions. The enamel, also, is similar to that in the preceding species.

Measurements.

Antero-posterior diameter of last upper molar........	7·1	lines.
Transverse diameter of same,........................	8·3	"
Antero-posterior diameter of penultimate upper molar,	8·	"
Transverse diameter of same,........................	8·	"

The principal specimens on which this species is established were found by H. D. Ziegler, in the Mauvaises Terres beds, near Marsh's Fork, Wyoming.

Lophiodon nanus, sp. nov.

A small, well marked species, apparently of the genus *Lophiodon*, is represented by a number of fossils collected by the Yale party at various localities. The most characteristic of these specimens is a right upper jaw containing a series of four premolars, and three molars, and part of the corresponding left jaw with several teeth of the same animal. The molars differ especially from those of the two preceding species, in having a much shallower valley between the two transverse ridges, and in having a strong basal ridge, or shelf, at the external posterior corner of the crown. The enamel of the whole series is very smooth. The species was probably about two thirds the size of *L. modestus.*

Measurements.

Length of portion of upper jaw, containing seven posterior teeth,	26·	lines.
Length of same, with three last molars,	13·7	"
Antero-posterior diameter of last upper molar,	5·	"
Transverse diameter of same,	5·25	"

The remains now known to represent this species were discovered by C. W. Betts, H. B. Sargent, and the writer, in the Tertiary strata at Grizzly Buttes, near Fort Bridger.

Lophiodon pumilus, sp. nov.

A still more diminutive species, of the same, or a nearly related, genus, is indicated by several specimens, including a fragment of a left upper jaw, containing three premolars and the two succeeding molar teeth. The species may easily be distinguished from the small one above described, by the presence, on the outside of the superior teeth, of a strong, continuous, but irregular basal ridge, which, at the external angle of the crown, replaces the elevated tubercle present in all the molars of the species already noticed. The present specimen may also be distinguished from *L. nanus*, by the form of the last two upper premolars, which in the latter have their greatest transverse diameter behind the center, while the reverse is true of these premolars in the species under consideration.

Measurements.

Length of portion of upper jaw, with three premolars, and next two molars,	14·	lines.
Antero-posterior diameter of penultimate upper molar,	3·25	"
Transverse diameter of same,	4·	"

The only specimens at present known to represent this species were found by C. T. Ballard, in the Tertiary beds near Marsh's Fork, Western Wyoming.

Anchitherium gracilis, sp. nov.

The Green River Tertiary basin of Wyoming apparently contains very few extinct solipedal mammals, one or two fragments only being all our party secured during several weeks of explorations. In the Uintah or southern basin, however, especially near the White River of Eastern Utah,* remains of this group are more abundant, and some characteristic specimens were obtained. Among these, were three lower jaws, with many of the teeth in good preservation. They represent an animal less than one half the size of *Anchitherium Bairdi* Leidy, and apparently belonging to the same genus. There are seven premolar and molar teeth, with essentially the same constitution as in that species. The first premolar has but one fang, and between this and the symphysis there are no teeth. On the inner face of each ramus there is a shallow, sickle-shaped impression, with the point directed forward, and terminating under the first premolar.

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* This Journal, vol. i, p. 196, March, 1871.

Measurements.

Length of portion of lower jaw, with six posterior teeth,	23·58	lines.
Length of same with three posterior teeth,	12·5	"
Antero-posterior diameter of last lower molar,	5·	"
Transverse diameter of same,	2·	"

The above specimens were discovered by C. T. Ballard and the writer, on the north side of the White River, in Eastern Utah. The geological horizon is upper Eocene, or lower Miocene.

Lophiotherium Ballardi, sp. nov.

A small Pachyderm, apparently nearly related to the genus *Lophiotherium*, is indicated by a fragment of a right lower jaw, with the last two molars, and a few less important remains. The species thus represented appears to have been about two thirds the size of *Lophiotherium sylvaticum*, recently described by Dr. Leidy from the same Tertiary basin in which these fossils were found,* and the teeth, so far as known, have nearly the same composition. Those preserved in the present specimen are somewhat worn, showing that the individual was fully adult. The enamel, especially on the sides of the crown, is much wrinkled, and thus the external basal ridge is rendered strongly serrated.

Measurements.

Antero-posterior diameter of last lower molar,	4·4	lines.
Transverse diameter of same,	2·1	"
Antero-posterior diameter of penultimate lower molar,	3·2	"
Transverse diameter of same,	2·25	"

The species is named for the discoverer, Mr. C. T. Ballard, of the Yale party, who obtained the specimens here described at Grizzly Buttes, Western Wyoming.

Elotherium lentus, sp. nov.

The presence of numerous Suilline Pachyderms in the Green River Tertiary basin was clearly established during the investigations of our party by the discovery of several extinct species, all different from any hitherto described. One of these, which evidently belonged to the genus *Elotherium*, is represented by a single fragment of a left lower jaw, with the last molar in fine preservation. This specimen indicates a species about one half the size of *Elotherium Mortoni* Leidy, which is comparatively abundant in the lower Tertiary deposits east of the Rocky Mountains. The upper surface of this last lower molar is composed of two transverse pairs of conical lobes, with a single posterior one on the median line. The anterior inner cone is larger than its fellow, and has its summit bifid. In the next pair, which are much less elevated, the external lobe is the larger. The posterior cone is low, and shows a tendency to subdivide. There is a basal ridge in front, and indications of its continuation on the external border. The enamel is finely corrugated. There is a prominent rugose tubercle on the inner superior margin of the lower jaw, a short distance behind and above the last molar.

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* Proceedings Philadelphia Academy of Natural Sciences, 1870, 126.

Measurements.

Antero-posterior diameter of last lower molar, ----------	9·	lines.
Greatest transverse diameter of same, ----------------	5·	"
Transverse diameter between first and second pair of cones,	4·4	"

The specimen on which this species is established was found by the writer, in October last, in the Tertiary beds, on Henry's Fork, Wyoming.

Platygonus Ziegleri, sp. nov.

Remains of another Suilline animal, fully as large as the modern *Sus scrofa*, were obtained in the same Tertiary beds with the last species. The most characteristic specimens discovered are a number of upper premolar and molar teeth, which agree so nearly in general composition with those of *Platygonus*, that they may very properly be referred to that genus. One prominent character in these teeth, especially the anterior ones, is the remarkably strong basal ridge, which, on the inner border at least of the first and second premolars, exceeds in breadth that in *Platygonus compressus* LeConte, although on the posterior margin it is less developed than in that species. The crowns of all the upper premolars are composed of a single transverse pair of cones, closely united. The second premolar in this specimen has a greater fore and aft diameter than the third. The enamel of all the teeth is rugose, as in the modern Peccaries.

Measurements.

Length of fragment of upper jaw, containing the three premolars, ----------------------------------	18·5	lines.
Antero-posterior diameter of first upper premolar, -----	6·	"
Transverse diameter of same, ----------------------	6·	"
Antero-posterior diameter of second upper premolar, --	6·5	"
Transverse diameter of same, ----------------------	7·3	"
Antero-posterior diameter of third upper premolar, ----	6·2	"

The species is named for H. D. Ziegler, of Yale College, who discovered the specimens on which the present description is based. The locality was at Grizzly Buttes, near the base of the Uintah Mountains.

Platygonus striatus, sp. nov.

A third Suilline species, nearly related apparently to the last, and quite equaling it in size, is indicated by portions of two lower jaws, with a few of the anterior teeth, collected by our party in the Pliocene strata of Northern Nebraska. In one of the specimens, the second left premolar is well preserved, and characteristic. It has the same general composition as the corresponding tooth in *Platygonus compressus*, but, in addition to its much larger size, it is proportionally broader, and has the basal ridge in front less developed. The posterior basal ridge, moreover, is expanded into two rudimentary tubercles. The enamel is marked by delicate irregular striæ, mostly parallel with the base of the crown, and to this ornamentation the specific name refers.

Measurements.

Length of portion of left lower jaw containing first four teeth,	25·	lines.
Length of same, with first three teeth,	17·	"
Antero-posterior diameter of second lower premolar,	6·2	"
Transverse diameter of same,	5·8	"

The above specimens were found by the writer, in July last, in the Pliocene sands, near the head-waters of the Loup Fork River, Nebraska.

Platygonus? Condoni, sp. nov.

The present species is founded on a portion of a right upper jaw containing the three posterior molars. The specimens evidently belonged to a true Suilline mammal, at least equal in size with the last two described. The exact generic relations of the species cannot at present be ascertained, but it differs essentially from any known recent or extinct American species of this group in several particulars. One of the most marked of these is the unusual elongated fore and aft proportions of the last upper molar, which has to the diameter of the penultimate tooth the ratio of three to two. The crown of the posterior molar is composed of two transverse pairs of principal cones, the front pair being the larger, and a posterior lobe, which is partially divided into three tubercles. The enamel is smooth, and there is no basal ridge on the sides of the teeth preserved.

Measurements.

Length of jaw enclosing last three upper molars,	27·	lines.
Antero-posterior extent of last molar,	12·	"
Transverse diameter of same, through anterior lobes,	7·	"
Antero-posterior extent of penultimate molar,	8·	"

This species is named for Rev. Thomas Condon, who discovered the specimen described, in the Pliocene beds of Oregon.

Dicotyles Hesperius, sp. nov.

A new and interesting small Suilline mammal is well represented by a portion of a right upper jaw, with the last premolar, and the succeeding three molars, all in excellent preservation. The teeth indicate an individual fully adult. They have nearly the composition of those of the modern Peccaries, and evidently belonged to the same, or a closely related, genus. The species is well marked, and was apparently not more than one half the bulk of *Dicotyles torquatus*. The crowns of the molars have a more rhombic outline than in that species, and a more distinct valley between the anterior and posterior pair of cones. The basal ridge is also more strongly developed, especially on the outer margin, where it is continuous. In other respects the composition of these teeth is very similar in the two species. The last upper premolar in the present specimen, however, differs widely from the corresponding tooth in any of the known Peccaries, living or fossil, resembling most nearly in its composition the second premolar of *D. torquatus*. The latter has, however, the single posterior cone distinct, while in the species under consideration it is connate with the anterior outer tubercle. The upper dental series is here somewhat curved outwardly, and not on a line, as in the living Peccaries.

Measurements.

Length of part of upper jaw with four posterior teeth,..	19·	lines.
Length of same, with three molars,..................	15·2	"
Antero-posterior diameter of last upper molar,.........	5·6	"
Transverse extent of same,..........................	4·	"
Antero-posterior diameter of penultimate upper molar,	5·4	"

This specimen, for which the writer is likewise indebted to Rev. Mr. Condon, is from the same locality and geological horizon as the species last described.

Hypsodus gracilis, sp. nov.

This species was about the same size as *Hypsodus paulus*, a small mammal described by Dr. Leidy from the lower Tertiary basin in Wyoming, and supposed by him to indicate an animal probably allied to the suilline family.* It may readily be distinguished from that species, especially by the first true molar of the lower jaw, which is proportionally narrower in front, and broader at its posterior margin. There is also on this tooth a strong external basal ridge, and, at the anterior inner angle, a prominent projection, which is wanting in *H. paulus*. The lower jaw is, moreover, deeper and more compressed in the region of the premolars.

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* Proceedings Philadelphia Acad. Nat. Science, 1870, p. 109.

Measurements.

Length of part of lower jaw containing first molar and last two premolars,	5·1	lines.
Antero-posterior diameter of first lower molar,	2·	"
Transverse diameter through posterior lobe,	1·6	"
Antero-posterior diameter of last lower premolar,	1·6	"

The specimens representing this species at present were found by the writer, at Grizzly Buttes, Wyoming.

Limnotherium tyrannus, gen. et sp. nov.

A somewhat larger pachyderm, but distantly allied apparently to the two small species last described, is represented by the anterior portions of two united lower jaws, with several teeth, and a few other fragmentary remains. These specimens appear to indicate a genus quite distinct from any hitherto known, but additional remains will probably be required to determine its exact affinities. The teeth of the lower jaws are twenty in number, and form an uninterrupted series, which may be divided as follows:—Incisors 2–2, canines 1–1, premolars 4–4, molars 3–3. The incisors are small, and crowded together. The canines are large, nearly round at the base, and evidently formed most efficient weapons. The first and second premolars had but a single fang. The two anterior molars are in excellent preservation, and have their crowns composed of four principal cones. The first is at the anterior outer angle; the second just behind this, on the inner margin; the third at the outer posterior angle; and the fourth and smallest at the inner posterior corner, separated from the others by a deep pit. Each molar has a rudimentary double tubercle on the anterior margin, and a moderate basal ridge, except on the inner side.

Measurements.

Length of dental series of lower jaw,	18·	lines·
Antero-posterior extent of three molars,	7·5	"
Transverse extent of four incisors,	3·	"
Length of symphysis,	8·5	"
Depth of lower jaw below last molar,	5·15	"
Depth below last premolar,	6·	"
Antero-posterior extent of first lower molar,	2·5	"
Transverse diameter of same,	2·	"

The specimens here described were found by the writer near Dry Creek, Western Wyoming, in deposits which are probably of Upper Eocene age.

Limnotherium elegans, sp. nov.

A diminutive mammal is represented in our collections by portions of two lower jaws, with several teeth, which have so nearly the composition of those in the preceding species that they undoubtedly belong to the same, or a nearly related genus. One of these specimens contains the last premolar, and the two succeeding molars. In the latter, the two anterior cones form a transverse pair, and are not oblique as in the larger species. The posterior pair of tubercles, also, are nearly on a transverse line.

Measurements.

Length of fragment of lower jaw, enclosing last premolar and three molars,	7·5	lines.
Antero-posterior diameter of second lower molar,	2·	"
Transverse diameter of same,	1·6	"

The only two specimens of this species now known were found by the writer at Grizzly Buttes, near the base of the Uintah Mountains, in Wyoming.

Yale College, New Haven, June 5th, 1871.

Art. IX.—*Contributions to Chemistry from the Laboratory of the Lawrence Scientific School.* No. 16.—*On the Atomic Weights of Cobalt and Nickel;* by Richard H. Lee.

The atomic weights of cobalt and nickel have long been subjects of controversy, but though much time and labor have been spent upon them, the results arrived at are not as satisfactory as could be desired.

Under these circumstances Prof. Gibbs suggested to me a new investigation of the subject. Before giving an account of my own methods and results, I will state briefly those of other chemists. Rothhoff,* in 1826, first endeavored to ascertain the atomic weights of cobalt and nickel. He determined the amount of chlorine in the respective chlorides, by means of silver, and from a single analysis of each chloride, obtained for cobalt the equivalent 29·55, and for nickel the equivalent 29·60. As the methods of separating the two metals were at that time imperfect, and as but a single analysis was made in each case, Rothhoff's results can hardly be considered as deserving of confidence.

Erdmann† and Marchand, in 1852, determined the atomic weight of nickel by reducing nickelous oxide in hydrogen. Their results varied between 29·1 and 29·3, and they regarded the lower number as more probably correct. It seems at least possible that the nickel they employed contained traces of cobalt. The subject was again taken up by Schneider‡ in 1857.

* Poggendorff's Annalen, vol. viii, p. 184–5.
† Annalen der Pharmacie, vol. lxxxii, p. 76.
‡ Poggendorff's Annalen, ci, p. 387.

Pure metallic cobalt was prepared by igniting chloride of purpureocobalt in hydrogen. The metal was then dissolved in chlorhydric acid and precipitated by sodic carbonate. The carbonate was washed, and then digested with oxalic acid, the resulting oxalate again washed, burned in a current of oxygen and the oxide reduced by hydrogen. In other portions of the oxalate the carbon was determined by combustion with cupric oxide.

The following table gives a summary of the results obtained:

	Oxalate taken.	Cobalt found.	Carbon found.	Equivalent Ȼo.
1.	1·6355 2·3045	32·552 pr. ct.	13·024 p. c.	29·993
2.	1·1070 1·9010	32·619 "	13·041 "	30·015
3.	2·3090 4·0580	32·528 "	13·005 "	30·014
4.	3·0070 5·3500	32·523 "	13·014 "	29·989
			Mean,	30·003

Determinations of the atomic weights of cobalt and nickel were also made in 1857 by Marignac.[*] Cobaltous sulphate was purified by repeated crystallization and a weighed quantity of the salt heated so as to expel the acid. The resulting oxide was then heated with a known weight of silicate of lead so as to expel the excess of oxygen over and above that required to form cobaltous oxide ȻoO. The results obtained varied between 29·32 and 29·38.

Crystallized cobaltous chloride dried at 100° was found to retain one atom of water. Three determinations of the chlorine in this salt by means of silver, gave for the atomic weight of cobalt 29·42 to 29·51. Anhydrous cobaltous chloride was obtained by heating the crystallized salt with sal-ammoniac, in a current of dry chlorine or dry chlorhydric acid gas. The salt almost always however left a slight residue insoluble in water. Five analyses of the anhydrous salt gave results varying from 29·36 to 29·42.

In 1859 Dumas[†] turned his attention to the subject. Perfectly pure metallic cobalt was dissolved in nitro-muriatic acid, the solution evaporated to dryness with frequent additions of chlorhydric acid, and the cobaltous chloride submitted to a red heat. In a second preparation from a different sample of metal the chloride was dried in vacuo. In this manner the following results were obtained:

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[*] Bibliothique Universelle de Geneve, Nouvelle series, vol. i, p. 373.

[†] Ann. de Chimie et de Physique, 3d series, vol. lv, p. 148.

	$CoCl_2$.	Silver.	Equivalent.
1	2·352	3·9035	29·57
2	4·210	6·990	29·54
3	3·592	5·960	29·59
4	2·492	4·1405	29·50
5	4·2295	7·0255	29·51

The mean of these five determinations is 29·54. In all cases the chloride was dissolved in boiling water and the solution allowed to cool before precipitating with $AgNO_3$. The argentic chloride was reduced in hydrogen. The method employed for the preparation of pure cobalt is not stated.

Russell* determined the atomic weights of cobalt and nickel in 1863. Pure metallic cobalt was prepared by igniting chloride of purpureocobalt in hydrogen. The metal was dissolved in nitric acid and the solution evaporated and strongly heated. The black oxide obtained was ignited in a current of carbonic di-oxide, by which it was converted into light brown cobaltous oxide ȻoO, which was then reduced by pure hydrogen. Omitting two trial experiments, the results obtained were as follows:

		ȻoO.	Cobalt.		Cobalt pr. ct.
First sample,	1	2·1211	1·6670		78·591
	2	2·0241	1·5907		78·588
	3	2·1226	1·6673		78·550
	4	1·9947	1·5678		78·598
	5	3·0628	2·4078		78·614
				Mean,	78·588
First specimen twice purified—					
	1	2·1167	1·6638		78·603
	2	1·7717	1·3924		78·591
	3	1·7852	1·4030		78·591
				Mean,	78·595
First specimen three times purified—					
	1	1·6878	1·3264		78·588
	2	2·2076	1·7350		78·592
				Mean,	78·590
Second specimen—					
	1	2·6851	2·1104		78·597
	2	2·1461	1·6868		78·598
				Mean,	78·597
Third specimen—					
	1	3·4038	2·6752		78·595
	2	2·2778	1·7901		78·589
	3	2·1837	1·7163		78·596
				Mean,	78·593

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* Annalen der Pharmacie, vol. cxxvi, pp. 322–336.

The mean of all the results is 78·5926, from which we find for the equivalent of cobalt on the old system 29·37.

In 1866 the subject was taken up by Sommaruga,* who determined the amount of metallic cobalt in chloride of purpureocobalt by reduction in a bulb tube with hydrogen. His results were as follows:

	Salt taken.	Cobalt found.	Equivalent.
1.	0·6656	0·1588	30·002
2.	1·0918	·2600	29·929
3.	0·9058	·2160	29·982
4.	1·5895	·3785	29·926
5.	2·9167	·6957	29·992
6.	1·8390	·4378	29·916
7.	2·5010	·5968	30·009
		Mean,	29·965

Winkler,† in 1867, determined the atomic weight of cobalt by heating a known weight of the metal with a perfectly neutral solution of double chloride of gold and sodium. The cobalt was obtained by the reduction of chloride of purpureocobalt.

	Salt taken.	Gold found.	Equivalent of Ȼo(Au=196.)
1.	0·5890	1·3045	29·497
2.	0·3147	0·6981	29·451
3.	0·5829	1·2913	29·492
4.	0·5111	1·1312	29·518
5.	0·5821	1·2848	29·522
		Mean,	29·496

Finally, in 1869, Weselsky‡ made a new determination of the atomic weight of cobalt by finding the quantity of metallic cobalt in weighed quantities of cobalticyanide of aniline-ammonium and of ammonium. The results were as follows:

	Cobalt salt.	Cobalt found.	Equivalent.
1.	0·8529 gr.	0·1010	29·44
2.	0·6112 "	0·0723	29·38
3.	0·7140 "	0·0850	29·59
4.	0·9420 "	0·1120	29·54
1.	0·7575 "	0·1160	29·46
2.	0·5143 "	0·1130	29·55
		Mean,	29·48

The first four analyses were made with the anilin, the last two with the ammonium salt. These are the only determinations of the atomic weight of cobalt which I have been able to find, and I will therefore pass to my own analyses.

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* Sitzungsberichte der Wiener Akad., vol. liv, p. 50.

† Zeitschrift für Anal. Chemie, 1867, p. 18.

‡ Berichte der Deutcshen Chem. Gesellschaft, 1870.

Commercial cobaltic oxide was treated in a large porcelain crucible with enough strong sulphuric acid to make it into a stiff paste. The crucible was then placed in a muffle furnace and heated for some time, at first gently and afterwards to low redness. The sulphate obtained was dissolved, filtered and submitted for some time to a current of sulphydric acid gas, by which copper, arsenic, &c., were removed. The filtrate was treated with chlorine water to peroxydize the iron present and then allowed to stand for 48 hours in contact with baric carbonate, the whole being frequently and thoroughly stirred. In this manner iron and manganese were almost wholly removed. The filtrate was then treated with a large excess of baric carbonate, and cyanhydric acid gas passed into the liquid until the whole of the cobalt was converted into cobalti-cyanide of barium, $Єo_2Cy_{12}Ba_3$. The solution of this salt was then boiled with mercuric oxide to separate the nickel present, as $NiCy_4Ba$, as well as traces of iron and manganese. The mercury was then removed from the filtrate by sulphydric acid gas, and the solution of cobalti-cyanide barium regarded as chemically pure. The methods which I adopted to determine the atomic weight of cobalt do not differ in principle from those of Weselsky and Sommaruga. I first formed cobalti-cyanides of alkaloids having high atomic weights and forming highly crystalline and perfectly definite double cyanides. I then determined the water of crystallization in these salts directly, and afterwards the percentage of cobalt in each. This last was effected by first carefully heating the salt in a platinum crucible by means of a ring-burner, and afterwards burning off the carbon, first in air and then in oxygen. Finally the cobalt was reduced to metal by a current of pure hydrogen, and weighed. In this manner but two weighings were necessary. In another series of experiments, I determined the amount of metallic cobalt in weighed quantities of chloride of purpureocobalt by igniting the salt in a current of pure hydrogen gas. To effect the reduction without loss, I employed an arrangement due to Dr. Gibbs, and consisting of a small thin disk of porous earthenware. The chloride of purpureocobalt was placed in a porcelain crucible and the disk of earthenware supported above it by the walls of the crucible. The hydrogen was introduced by a tube passing into the bored cover and the crucible was then carefully heated from above. In this manner the gas diffused through the porous septum, which in turn served to prevent the escape of any particles of solid substance. The reduction was absolutely complete, and the metal did not oxidize after slowly cooling in an atmosphere of hydrogen. In the analyses made in this manner, also, but two weighings were necessary.

In my first series of experiments I employed only the cobalti-cyanides of brucine and strychnine, the corresponding salts of morphine, narcotine, chinine and cinchonine having been found difficult to prepare in a state of purity by recrystallization. The brucine and strychnine salts were prepared by decomposing the sulphates of these bases with cobalti-cyanide of barium, and repeatedly recrystallizing the salts formed. The brucine salt crystallized in beautiful white, barb-shaped crystals with a high luster. It was but slightly soluble in cold water, and crystallized with remarkable facility. The strychnine salt was in beautiful, nearly colorless needles, and like the brucine salt crystallized almost completely from its solution on cooling. Six analyses were made with each of these salts.

Of the strychnine salt—

0·7084 gr. dried at 115°C. lost 0·0392 gr. of water = 5·53 p. c. The formula, $Co_2Cy_{12}(C_{21}H_{22}N_2O_2)_6H_6+8OH_2$, requires 5·57 p. c. water of crystallization.

The following are the results of my determinations of the amount of cobalt in this salt:

No.	Salt taken.	Cobalt.	Cobalt, p c.	At. weight.
1.	0·4255 gr.	0·0195 gr.	4·583	59·22
2.	0·4025 "	0·0185 "	4·596	59·36
3.	0·3733 "	0·0170 "	4·554	58·83
4.	0·4535 "	0·0207 "	4·564	58·96
5.	0·2753 "	0·0126 "	4·577	59·14
6.	0·1429 "	0·0065 "	4·549	58·76
		Mean,	4·5705	59·05

The probable error of the mean is ±0·012, and the atomic weight of cobalt 59·05, with a probable error of ±·156. In the case of the brucine salt, three determinations of the water of crystallization were made.

0·4097 gr. gave 0·0465 gr. water at 117° C. = 11·35 p. c.
0·3951 gr. " 0·0453 gr. " 119° C. = 11·46 p. c.
0·6653 gr. " 0·0752 gr. " 128° C. = 11·30 p. c.

The mean of these three determinations is 11·37 p. c.

The formula $Co_2Cy_{12}(C_{23}H_{26}N_2O_4)_6H_6+20\Theta H_2$ requires 11·39 p. c. water of crystallization.

The results of my determinations of the amount of metal in this salt are as follows:

	Salt taken.	Cobalt.	Cobalt, p. c.	At. weight.
1.	0·4097 gr.	0·0154 gr.	3·759	59·41
2.	0·3951 "	0·0147 "	3·720	58·76
3.	0·5456 "	0·0204 "	3·739	59·08
4.	0·4402 "	0·0165 "	3·748	59·22
5.	0·4644 "	0·0174 "	3·747	59·21
6.	0·4027 "	0·0151 "	3·749	59·24
		Mean,	3·7437	59·15

The probable error of the mean is here ±0·0088, and the atomic weight of cobalt 59·15, with a probable error of ±·146.

The method of analyzing the chloride of purpureocobalt has already been described. The results of my analyses are as follows:

No.	Salt taken.	Cobalt.	Cobalt, p. c.	At. weight.
1.	0·9472 gr.	0·2233 gr.	23·575	59·07
2.	0·8903 "	0·2100 "	23·587	59·11
3.	0·6084 "	0·1435 "	23·586	59·11
4.	0·6561 "	0·1547 "	23·579	59·08
5.	0·6988 "	0·1647 "	23·569	59·05
6.	0·7010 "	0·1653 "	23·581	59·09
		Mean,	23·5795	59·09

The probable error of the mean is here ±0·004, and the calculated atomic weight 59·09, with a probable error of ±·0146.

The mean of my eighteen determinations of the atomic weight of cobalt is 59·10. For the sake of comparison I give here the results obtained by other observers, in tabular form, reduced to the modern scale of atomic weights:

Rothhoff,	59·10	Dumas,	59·08	Winkler,	58·99
Schneider,	60·00	Russell,	58·74	Weselsky,	58·96
Marignac,	58·84 to 59·02 58·72 to 58·84	Sommaruga,	59·93	Lee,	59·10

Nickel.—The atomic weight of nickel was also first determined by Rothhoff* in 1826, by determining the amount of chlorine in a weighed quantity of nickelous chloride. A single experiment gave for the equivalent 29·60, a number which is probably too high, in consequence of the imperfection of the processes known at that time for the separation of nickel from cobalt. Erdmann and Marchand took up the subject in 1852.† Nickelous oxide prepared by various processes was reduced in a current of hydrogen and the metal weighed. No data are given, but the authors state that their results varied between 29·1 and 29·3, and that they consider the lower number more probably correct.

Schneider,‡ in 1857, also determined the atomic weight of nickel. Pure nickelous oxalate was burnt with cupric oxide to determine the oxalic acid, while the amount of metallic nickel was obtained by reducing the oxide with pure hydrogen. In this manner Schneider obtained as the mean of four analyses the number 29·02.

Marignac,§ in 1857, determined the atomic weight of nickel by methods precisely similar to those employed by him in the case of cobalt already cited. His analyses of the sulphate of nickel gave results varying from 29·2 to 29·5, while those of the chloride gave results varying between 29·4 and 29·64. Marignac does not give his method of obtaining pure salts of nickel.

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* Pogg. Ann., vol. viii, p. 184.
† Ann. der Pharmacie, lxxxii, p. 76.
‡ Pogg. Ann., ci, p. 387.
§ Bibliothique Universelle de Geneve, Nouvelle Series, vol. i, p. 373.

The subject was next investigated by Dumas,* who determined the quantity of chlorine in nickelous chloride, and obtained for the equivalent of nickel as a mean of five analyses the number 29·514. The author does not give the process by which the nickel was obtained free from cobalt.

Russell† took up the subject of the atomic weight of nickel, together with that of cobalt, in 1863. Pure nickelous oxide was first ignited in a current of carbonic di-oxide, and afterward in pure hydrogen. His results were as follows:

						Metal.
1st specimen,	mean	of 3 determinations	100 parts	of oxide,	gave	78·596 Ni.
2.	"	"	"	"	"	78·584 "
3.	"	"	"	"	"	78·598 "
4.‡	"	"	"	"	"	78·592 "

The mean of all the determinations gave for the quantity of nickel in 100 parts of the oxide 78·5925, and for the atomic weight of nickel 58·74.

In 1866, Sommaruga§ determined the atomic weight of nickel by ascertaining the quantity of sulphuric acid in pure crystallized double sulphate of nickel and potassium. The mean of six analyses gave for the equivalent of nickel the number 29·013, with a probable error of ±0·079.

Winkler,‖ in 1867, employed the method of reduction already described. The mean of four analyses gave for the equivalent 29·527, with a probable error of ±0·056.

With these preliminary statements I pass to an account of my own methods and results. Metallic nickel of commerce was dissolved in nitro-sulphuric acid, and the nitric acid expelled by heat. The sulphate was then dissolved in water and the traces of copper and arsenic removed by a long continued current of sulphydric acid gas. The iron in the filtrate was then oxydized by means of bromine, and precipitated by agitation with Ba Co_2. The cobalt was removed by potassic nitrite and the nickelous sulphate then converted into nickel-cyanide of potassium, which was recrystallized. This salt contained only a trace of cobalt, after four crystallizations. To determine the atomic weight of nickel I adopted the method already employed to determine that of cobalt. I first formed the double cyanides of nickel with brucine and strychnine, and then determined, first the quantity of water in each of these salts, and afterward the percentage of metallic nickel. This last determination was effected by first carefully heating the salt in a platinum crucible, employing the ring-burner of Dr. Gibbs so as to apply the heat at the rim of the crucible first, and afterward in successive zones until the bottom of the crucible was reached. The remaining carbon was then burned off in a current of pure oxygen, and the oxide of nickel finally reduced by igniting it in carefully purified hydrogen. The double cyanides of nickel, brucine and strychnine were prepared by double decomposition, the salts being but slightly soluble in cold water. They were then repeatedly recrystallized, and when tested by the spectroscope were found to be absolutely free from potassium. All of these salts crystallized in very pale yellow needles.

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* Ann. de Chimie et de Physique, 3d series, vol. lv, p. 148.

† Ann. der Pharmacie, vol. cxxvi, p. 322 to 336.

‡ Second purification.

§ Sitzungsberichte der Weinen Akad., vol. liv, p. 50.

‖ Zeitschrift für Analyt. Chemie, 1867, p. 18.

My analyses of the brucine salt led to the following results:

0·4496 gr. dried at 120° C. lost 0·0258 gr. ΘH_2=5·738 p. c. water.

The formula $Ni_3Cy_{12}(C_{23}H_{26}N_2O_4)_6H_6+10\Theta H_2$, requires 5·929 p. c.

No.	Salt taken.	Nickel.	Nickel, p. c.	At. weight.
1.	0·3966	0·0227	5·724	57·92
2.	0·5638	0·0323	5·729	57·98
3.	0·4000	0·0230	5·750	58·20
4.	0·3131	0·01795	5·733	58·02
5.	0·4412	0·0252	5·712	57·79
6.	0·4346	0·0249	5·729	57·98
		Mean,	5·7295	57·98

The probable error of the mean percentage of nickel is ±0·008, and the atomic weight of nickel 57·98, with a probable error of ±0·089.

Six analyses of the strychnine salt were then made:

0·3399 gr. dried at 112° C. lost 0·0178 gr. water = 5·24 p. c.

The formula $Ni_3Cy_{12}(C_{21}H_{22}N_2O_2)_6H_6+8\Theta H_2$, requires 5·45 p. c.

No.	Salt taken.	Nickel.	Nickel, p. c.	At. weight.
1.	0·5358	0·0354	6·607	58·15
2.	0·5489	0·0363	6·613	58·21
3.	0·3551	0·0234	6·589	57·98
4.	0·4495	0·0297	6·607	58·15
5.	0·2530	0·0166	6·561	57·72
6.	0·1956	0·0129	6·595	58·04
		Mean,	6·595	58·04

The probable error of the mean percentage of nickel is ±0·013, and the atomic weight 58·038, with a probable error of ±0·119.

The mean of all my determinations of the atomic weight of nickel is 58·01. The following table gives all the determinations made:

Rothhoff,	59·20	Dumas,	59·028
Erdmann and Marchand,	58·20 to 58·60	Russell,	58·74
		Sommaruga,	58·026
Schneider,	58·04	Winkler,	59·054
Marignac,	58·40 to 59	Lee,	58·01

In conclusion, my thanks are due to Dr. Gibbs for the selection of the subject of my work, and for his advice during the course of my investigation.

Cambridge, May, 1871.

Art. X.—*Note on the Spectrum of the Corona*; by Prof. C. A. Young.

In an article upon the Solar Corona, which appeared in the May number of this Journal, I wrote, "very perplexing also is the fact that the faint continuous spectrum, which must be in part produced by this polarized component of the corona's light, shows no discoverable traces of the dark lines of the ordinary sunlight-spectrum. Probably they exist, but are in some way masked so that they are not easily detected."

On further reflection, however, I believe the matter is readily explained. and that on the other hand it would have been remarkable if we had been able to bring out the Fraunhofer lines.

The truth is that the reflected photospheric sunlight forms only one small fraction of the total coronal radiance, the other constituents of which so far preponderate that it becomes very difficult to detect in the general spectrum the characteristics of this reflected light.

The spectrum of the corona is, in all probability, composed of at least *four* superposed elements.

1st. A continuous spectrum, without lines either bright or dark, due to incandescent dust—that is, to particles of solid or liquid meteoric matter near the sun. For although I am not able to admit with Mr. Proctor that the whole explanation of the corona is involved in the presence of such meteoric particles, yet it cannot be doubted that they are very numerous; and any that may come within 250,000 miles of the solar surface must become incandescent and give such a spectrum as described.

2nd. A true gaseous spectrum of the second order, consisting, like all such spectra, of a more or less bright continuous background with well marked maxima or bright lines. In this case one bright line (1474) certainly exists, and perhaps several. So far as the spectroscopic evidence goes this gas may be simply the vapor of the meteoric dust above alluded to, liberated by the heat of the sun, as when powdered sodium is dropped into an alcohol flame; or it may be disengaged for the instant from the same particles by electric discharges between them, as when the bright lines of metallic vapor appear in the spectrum of the spark produced by an induction coil. But in my previous article I have stated reasons for believing that the gas is of a more permanent character—a solar atmosphere through and in which the meteoric particles move as foreign bodies.

3rd. A true sunlight-spectrum (with its dark lines) formed by photospheric light reflected from the solar atmosphere and meteoric dust. To this reflected sunlight undoubtedly is due most of the polarization, and were it possible to separate the polarized component of the coronal light from the rest, we might perhaps hope to find in it traces of the Fraunhofer lines. It is by no means impossible, however, that the spectroscopic character of reflected light may undergo some change, such as a partial obliteration or degradation of its lines, when the reflecting particles are sufficiently minute—small, that is as compared with the dimensions of a wave of light, so that they do not merely reflect the undulation at their surfaces, but themselves enter into motion bodily. Experiments upon the spectrum of the light emitted by one of the so-called actinic clouds would, perhaps, clear up the subject.

4th. Another component spectrum is due to the light reflected from the particles of our own atmosphere. This is a mixture of the three already named, with the addition of the chromosphere spectrum; for while at the middle of an eclipse the air is wholly shielded from photospheric sunlight, it is of course exposed to illumination from the prominences and upper portions of the chromosphere. This light from the terrestrial atmosphere, like that reflected by particles near the sun, is evidently partially polarized in radial planes.

And if there is between us and the moon, at the moment of eclipse, any cloud of cosmical dust, the light reflected by this would come in as a *fifth* element. It would, however, only differ from that reflected by our own atmosphere by including a greater or less modicum of photospheric sunlight.

Furthermore, in instruments like those employed by Messrs. Abbay and Pye, the chromosphere spectrum overlies that of the corona, and increases the complication.

It would seem, therefore, that only a small percentage of the light which falls upon the slit of the spectroscope during a total eclipse contains the Fraunhofer lines at all, and it ought not to be considered strange that they are not readily observed.

In the same article I have stated that the photographs, taken by the American party in Spain, appear to differ essentially from those obtained by Mr. Brothers, in Sicily. This statement was based upon a comparison instituted by Mr. Lockyer, Professor Winlock and myself, between a copy of the American photograph and a drawing* of Mr. Brothers' photograph, which (drawing) he had himself sent to Mr. Lockyer.

There was a general and even striking agreement between the two in respect to the position of the 'gaps' and the distribution of the luminosity, yet there certainly were, as Mr. L. pointed out, very noticeable and important differences, and of a character to suggest that the extensive outside radiance might probably be of a less permanent character than the leucosphere, and of a different origin.

But I understand that when photographic copies of Mr. Brothers' and the American negatives are made to a common scale then these differences disappear and the agreement becomes nearly absolute in respect to all essential particulars. If this be so, it certainly bears very strongly in favor of those theories which assign a purely solar origin to the whole phenomenon.

Dartmouth College, May 10, 1871.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *Note on Para-sulphobenzoic Acid;* by Ira Remsen, M.D., Ph.D., Assistant in the University laboratory, Tübingen, Germany. —In my former note, (volume i, page 462), I stated that when ordinary sulphobenzoate of potassium is fused with hydrate of potassium, a mixture of oxybenzoïc and para-oxybenzoïc acids is always formed, instead of pure oxybenzoïc acid, as was up to that time supposed. From this fact I concluded that two salts must be contained in ordinary sulphobenzoate of potassium.

In order to decide this point, I separated the free acid from the same potassium salt that had been made use of for the first experiment described in the note mentioned. This was accomplished by decomposing the salt with the necessary quantity of sulphuric acid, evaporating to dryness and extracting with alcohol. With the acid mixture obtained I prepared an acid barium salt, by neutralizing with carbonate of barium, dividing the solution into two equal parts, precipitating the barium from the one exactly with sulphuric acid and then mixing the two again. On evaporating this solution, it became filled with beautiful needles on cooling.

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* I am not sure but we had a photographic copy of Mr. Brothers' drawing instead of the drawing itself; but we did not have a photographic copy of the original negative. No such copies had then been made.

These did not possess the least resemblance to the crystals of the known acid barium salt of sulphobenzoïc acid. They were filtered off and recrystallized. Their form was not changed by this process. The salt was now repeatedly recrystallized from water and each time it separated in needles which became longer and more beautiful, the finer they became. It was dried by being allowed to stand for some time over sulphuric acid, and then subjected to analysis. It contained water of crystallization, which was not driven off at a temperature lower than 250–260°. The salt has the formula $(C_{14}H_{10}S_2O_{10})\ Ba+3H_2O$. The analyses gave the following numbers:

Found, H_2O 8·95 pr. ct. and 9·38 pr. ct.
Ba 25·34 pr. ct. and 25·38 pr. ct.
Calculated, H_2O 9·10 pr. ct. Ba 25·41 pr. ct.

The mother liquor from these needles was now evaporated, and in this way a salt of entirely different appearance was obtained. After being recrystallized it formed very regular, beautiful monoclinic crystals, which resembled the known acid sulphobenzoate of barium in every respect. This salt was also analyzed and the same formula found for it as for the needles. The water of crystallization escaped at 200°.

Found, H_2O 9·34 pr. ct. Ba 25·56 pr. ct.
Calculated, H_2O 9·10 pr. ct. Ba 25·41 pr. ct.

Although the decided difference in the solubility of the salts and in their crystalline form, which constantly presented itself, made it exceedingly improbable, it was still possible that two different conditions of the same salt were here under observation and not two isomeric salts, particularly as the analyses had shown them to contain the same number of molecules of water of crystallization. There was hence still an experiment necessary to prove the isomerism. The two barium salts were converted into the neutral potassium salts and these melted into hydrate of potassium.

The potassium salt that was obtained from the needles, yielded perfectly *pure para-oxybenzoïc acid* as the only product of the reaction. The acid showed all the characteristic signs of para-oxybenzoïc acid. The crystalline form was the same. It contained water of crystallization, which was given off at 100°. Its melting point was exactly 210°. The crystals were very regularly formed and possessed a mother-of-pearl luster.

The nature of the salt that crystallizes in needles is thus explained. It is a salt of *para-sulphobenzoïc acid.*

Acid para-sulphobenzoate of Barium is difficultly soluble in hot water (much more so than the known corresponding salt of metasulphobenzoïc acid), and almost insoluble in cold water. When pure it crystallizes from a hot solution during the process of filtering. If it be now redissolved and allowed to stand quietly, beautiful flattened needles are found in the solution, which fill the entire vessel from top to bottom.

The *neutral potassium salt* is very easily soluble in hot, as well as in cold water, and crystallizes from its concentrated solution in needles. Owing to a want of material it was not analyzed.

The potassium salt, obtained from the monoclinic barium salt, on being fused with hydrate of potassium, yielded only oxybenzoic acid, as anticipated.

The principal product of the action of sulphuric acid on benzoic acid is then meta-sulphobenzoïc* acid, while at the same time there is produced in all cases a certain amount of the para-acid. As may be seen from the experiments described, there are conditions which are just as favorable for the production of the para-acid as for that of the meta-acid. I have as yet however but once succeeded in meeting these conditions, notwithstanding the fact that a large number of experiments were made with this object. I first repeated the preparation of sulphobenzoïc acid, retaining as closely as possible the conditions under which the first preparation took place; the chief product was not the para- but the meta-acid. Owing to this want of success I have not been able to study the properties of para-sulphobenzoïc acid better. Although its formation was proven under all and the most varied circumstances, the quantity was too small and its separation too difficult to admit of isolation. When present in larger quantity than the meta-acid, as was the case in the experiment mentioned above, the separation by means of the acid barium salts is very simple. If, however, the meta-salt predominates, on evaporating the mother liquor from the first crystallization both salts crystallize out together, forming crystals entirely different from either of the pure salts, and these may be recrystallized repeatedly without effecting their separation into their components.

I am continuing my experiments with the object of discovering the conditions of the formation of the para-acid. At the same time I shall attempt to prepare the same acid by the oxidation of para-sulphotoluolic acid, and will probably soon be able to report on its properties more exhaustively.

Tübingen, May 16.

II. Geology and Natural History.

1. *Mineral silicates in Fossils;* by T. Sterry Hunt. (Communicated).—Since the discovery of a mineral silicate injecting fossils in a paleozoic limestone from New Brunswick, Dr. Dawson has examined a great many limestones from different localities, to obtain further facts which might serve to throw light on the history of Eozoon. A remarkable example of a similar phenomenon has been found by him in a limestone from the collection of the late Dr. Holmer, marked Llangedoe (Wales), and preserved in the Museum of McGill College. The rock is granular crystalline, and made up of organic remains, chiefly fragmentary, for the most part infiltrated by a silicate similar to that from Pole Hill, New Brunswick. The only perfect fossil detected by Dr. Dawson

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* Meta = 1·3.

is a small coral-like body referable to the genus Verticillopora, an Upper Silurian form. The limestone includes besides, however, joints and plates of crinoids, small spiral gasteropod shells, with fragments of brachiopods and of a sponge-like organism with square meshes. All of these fossils are more or less penetrated with a greenish silicate, which fills the cavities of the gasteropods, the central canal of the crinoids and the pores of the Verticillopora. It has also replaced or filled the spongy fibers and injected the minute cells of some of the crinoidal fragments, though many of these are solid and calcareous throughout, in which respect the specimen differs from that from New Brunswick, described in this Journal for May, 1871 (p. 379), where the infiltration of the crinoidal remains is much more complete and perfect. Dr. Dawson, to whom we owe these observations, supposes that in both cases the infiltration took place while the remains were still recent.

Decalcified surfaces of the limestone show similar appearances to those presented by the New Brunswick specimens; the casts of small shells like Murschisonia, two millimeters in length, are in some cases perfect. The limestone is nearly pure, with the exception of a little fine yellow ochreous mud, which is insoluble in dilute hydrochloric acid, and remains suspended in the solution, but is easily separated by washing from the pale greenish-gray silicate. This equals about three per cent of the weight of the limestone. When ignited in the air it assumes a bright fawn color, and under the microscope then contrasts strongly with the colorless grains of quartz or other hard siliceous minerals with which it is mixed. Its analysis by Mr. Sterry Hunt in the manner described for the New Brunswick mineral shows that it scarcely differs from this except in being more hydrated and almost identical with jollyte. It gave, after deducting 21·0 per cent of insoluble sand, the following composition for one hundred parts: Silica 35·32, alumina 22·66, protoxide of iron 21·42, magnesia 6·98, potash 1·49, soda 0·67, water 11·46 = 100·00.

2. *Mastodon remains in Central New York;* by B. G. Wilder. (Communicated.)—Five teeth and many bones and fragments of the Mastodon have been discovered in a deposit of modified drift near Ithaca, New York, and placed in the Museum of Cornell University. Many more remains will doubtless be obtained, as the teeth already indicate the existence of two or more individuals; little hope is entertained, however, of finding a perfect skeleton.

3. *Fucoids in the Coal measures of Iowa.*—Prof. White, in his "Geology of Iowa" (vol. i, p. 241), notices the occurrence of forms identical with or allied to *Caulerpites marginatus*, in the Lower Coal-measures of Wapello county, Iowa, and of other forms, more or less indistinct, in the higher portions of the series (see p. 281, l. 4).
F. H. B.

4. *Phosphatic Sand in South Carolina.*—Prof. C. U. Shepard has described a deposit of sand over the phosphatic nodular bed of Stone River, which has resulted from the wear of the latter by the waters, and in some places is at least six feet thick. A portion

of it, after drying in the air, was found to contain 27 p. c. of the phosphate of lime, with 63·5 of fine (nearly impalpable) and coarse sand, 3·0 of carbonate and sulphate of lime, 6·5 moisture and organic matter. By agitation in water the lighter flocculent siliceous part may be floated off, and the phosphatic portion thus concentrated to 37 per cent of the remainder. Prof. Shepard observes that this sand deposit appears to be very extensive. He suggests that it may require, after washing, to be treated with sulphuric acid, at the rate perhaps of 100 pounds to the ton; the phosphoric acid would thus be rendered partially soluble. He observes that the phosphate is in too impure a state for railroad exportation, but "for use on lands contiguous to water its future value cannot be doubted."—*Rural Carolinian*, May, 1871.

5. COUES *on Antero-posterior Symmetry.*[*]—That the anterior and posterior limbs of vertebrates are homologous is now admitted by all; but the majority of anatomists hold that they are to be compared as *parallel* parts, while a few[†] believe that they should be compared as symmetrical or antagonistic parts, as are the right and left sides; the former relation may be called "Syntropy," the latter, "Antitropy;" and the advocates of these ideas, "Syntropists" and "Antitropists" respectively.

The latter have lately been joined by a vigorous ally, to whose work attention has already been called;[‡] and the accession is the more opportune because some recent English writers[‖] upon intermembral homologies have regarded the question as already decided in favor of Syntropy, and in the determination of muscular homologies they take for granted that pollex (thumb) is the homologue of primus (great toe), whereas the antitropists above mentioned regard the relation between them as one of analogy only, the pollex being the true homologue of quintus (little toe) and the primus of minimus (little finger). The propriety of this view is admirably presented by Wyman,[§] together with the obvious objections thereto and the grounds upon which these objections may be removed.[¶]

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[*] Antero-posterior Symmetry with special reference to the Muscles of the Limbs; by ELLIOTT COUES, M.D., Assist. Surg. U. S. A.; New York Medical Record, July, 1870, et seq., pp. 149–152, 193–195, 222–224, 272–274, 297–299, 370–372, 390–391, 438–440.

[†] Agassiz, Dana, Foltz, Wyman and the writer.

[‡] American Naturalist, May, 1871.

[‖] Flower, Humphrey, Mivart, Rolleston.

[§] Symmetry and Homology in Limbs, Proc. Bost. Soc. Nat. Hist., June 5th, 1867.

[¶] The general and special questions here involved have been discussed by me at several times since they were first suggested to me by a verbal communication of Prof. Wyman to the Bost. Soc. Nat. Hist., June 6th, 1860: and I shall shortly publish a somewhat extended paper upon the subject, (Proc. Bost. Soc. Nat. Hist., Apr. 19th. 1871) containing the following:

1. An historical sketch of the question. 2. A revision of the nomenclature of parts. 3. A revision of the nomenclature of ideas. 4. Evidence as to the morphical inconsequence of numerical composition. 5. Indication of general problems. 6. Indication of special problems. 7. Chronological list of 76 special works upon intermembral homologies. 8. Alphabetical list of 227 collateral works.

Dr. Coues follows closely in the footsteps of his distinguished predecessor, "not blindly, but unable not to see the validity of his arguments," (195) and therefore, with a few minor differences or doubts respecting details, adopts the osseous homologies of Wyman as the basis for the determination of "muscular correspondences." In respect to these latter, although Dr. Coues is led to differ materially upon some points from my own previous conclusions, yet he has generally shown such good reason therefor, that my praise of this part of his work is unqualified, and I am anxious to go over the whole ground anew in the light of his able discussion. To consider his arguments and conclusions in detail would require a paper equal in length to his own, and I reserve this task for some future occasion when his later and most instructive paper upon the myology of Ornithorhynchus can be included; the general and special problems involved are discussed at some length in the paper already referred to.

But while ready to express the most hearty admiration of Dr. Coues' labors, and confidence in his ability to even surpass them in future, I am forced to criticise some of his methods. In the first place he has "no acknowledgments to make" excepting to three[*] (149), and therefore, whatever satisfaction may be derived from having so taken up the subject fresh, he has also lost the benefit of the checks which an acquaintance with many and different views exerts upon the tendency to the exclusive adoption of any one; and he has thus, as it seems to me, been led to adopt a faulty method from each of his predecessors.

He has unconsciously imitated Owen in the use of many different and often ponderous expressions for the same idea "in order to avoid monotony,"[†] whereas, in homologies, as in mathematics, each object and idea should be known by a single term, and by that alone; since, of all the natural sciences, this demands the closest attention, and the absence of all secondary considerations.

Dr. Coues has accepted unquestioned the view of the normal position of the membra for comparison which was first proposed by Wyman, and adopted by Foltz, Folsom and myself; this view is based upon the proposition of Wyman, (op. cit. 265) that "the knees and elbows in all animals are bent so as to form angles pointing in opposite directions;" if we except the fishes, this generalization is correct, *provided* the membra are placed in the position they have with most quadrupeds; but Goodsir, Humphrey, Huxley and Wyman himself have shown that this is not their *primary* position, and it is quite possible that Wyman and Coues might have followed Huxley in denying that it is their *normal* position, had they read his paper; the desire to admit this radical change in my own views upon this point was one of the chief motives for the preparation of the paper already referred to, since doing so involves a concession, though not essential one to the idea of syntropy.

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[*] Owen, Wyman and the writer.

[†] As for instance, "*two-jointed* thumb" is coupled with "*biarticulated* great toe." p. 193; and in a few cases there is tautology, as in "morphologically homologous" and "teleologically analogous," p. 194.

Finally, Dr. Coues has accepted from the writer a nomenclature of ideas, (Antitypy, &c.,) which was itself based upon Owenian phraseology, which was in no way expressive of the ideas designated thereby, and which I now propose to discard for a more significant nomenclature derived from a term (Antitropy) already in use. I have commented upon some of Dr. Coues' methods the more freely, in part because of my unqualified admiration of his real individual work, but chiefly because as regards the use of many and long words, and the acceptance of the peculiar views of single authors, my own sins have been more and greater than his can ever be. B. G. W.

6. *Supplement to "Annélides chétopodes du Golfe de Naples."*—Claparède has published a Supplement to the Annelids of the Gulf of Naples especially interesting for its complete observations on the singular phenomena of reproduction of the Nereids, which were barely suspected at the time the principal part of his monograph appeared.

Malmgren in 1864 was first led to suspect a genetic relation between Nereis and Heteronereis, from a comparison of *Nereis pelasgica* and *Heteronereis grandifolia*, showing nearly an absolute identity, with the exception of the peculiar foliaceous appendages and bristles of the posterior part and other minor characters only developed at the period of sexual maturity. This led him to look upon certain species of Nereis as the agamous stock of sexual individuals appearing as Heteronereis. Subsequently having found eggs in this presumed agamous Heteronereis stock, he came to the conclusion that, although all the species of Iphinereis and Heteronereis were only sexual forms in series of generations still unknown, yet that at some time, during sexual maturity a stage of one of the polymorphous species of Nereis assumes the characters of Heteronereis, to lose them subsequently and return to its agamous stage. Malmgren accounted for the genetic relations by an alternate generation at first, and afterwards by a metamorphosis; both of which hypotheses Claparède shows conclusively are justifiable. Ehlers has shown that a large number of species of Heteronereis were only sexual forms of previously known species of Nereis, and interprets these facts in favor of a metamorphosis of Nereis into Heteronereis.

This was the condition of the problem when Claparède resumed the subject and showed conclusively (from the study of living Annelids) that there is a genetic relation between Nereis and Heteronereis, but he shows as conclusively that all Nereids do not have their Heteronereis form, as had been taken for granted by Ehlers, and that there is in the Annelids of this family a polymorphism almost without parallel in the animal kingdom. Taking the species which he has most carefully studied (*Nereis* (*Leontis*) *Dumerillii*) we have first a sexual form as Nereis, two sexual forms as Heteronereis, and a fourth hemaphrodite form discovered by Mecznikow. Large full grown specimens of *Nereis Dumerillii* are all transformed into Heteronereis, while the small diminutive individuals alone become matured as Nereis. Of the two sexual forms of Heteronereis one is small, extremely active, swimming freely about and eminently pelasgic, the other is sluggish, remaining more or less stationary at the bottom of the sea. The variations in size of individuals becoming sexual as Nereis or changing into Heteronereis are considerable, and it may be that a species can arrive at maturity in all stages of growth, may subsequently lose all traces of its sexuality, increase in size and in number of segments, to take on late again sexual characters and be transformed into Heteronereis. Absolute certainty of the sequence of these changes can only be obtained by tracing them in an aquarium.

This Supplement is illustrated by fourteen excellent plates, completing data left more or less imperfect in the first part. There are excellent observations, and figures, on the eyes of Alciopidæ, confirmatory of former papers by Krohn and Leydig on the same subject, adding many new points of considerable physiological importance. In the preface, Claparède promises us an extended memoir on the histology of Annelids (for which he has many thousand admirable preparations), he calls attention to the restoration of many specific names first introduced by Delle Chiaje which have usually been neglected. As a mark of his appreciation of Delle Chiaje's work he fittingly dedicates to him the closing chapters of this excellent contribution to the fauna of the Bay, where he worked so long and so successfully. A. AG.

7. *Diapensiaceæ.*—To the account of this small group of plants, as given in a paper entitled: "*Reconstruction of the order Diapensiaceæ*, presented to the American Academy in June, 1870, and issued at the close of the year, Dr. Maximowicz, in the ninth decade of his *Mélanges Biologiques*, published by the St. Petersburgh Academy this spring, has added some interesting comments and observations. He first remarks that he not only approves of the association of *Schizocodon* and *Galax* with *Diapensia*, but had himself suggested it in the year 1867, in a letter to Prof. Bunge, who had responded in favor of the suggestion. He also now concludes that both *Shortia* and *Shizocodon* are probably to be maintained as genera; the former including *Schizocodon uniflorus* as a second species is most likely distinct from the Alleghanian plant and clearly different from *Schizocodon soldanelloides*. This opinion is grounded mainly upon a drawing, which apparently represents the plant in question, in a Japanese work in his possession, and which exhibits the corolla, this, curiously enough, being wanting in the about 30 known specimens of the Japanese plant, as well as in the solitary American specimen. The closely adherent testa of the seed and the slender style are the most marked characters.

In the same publication Dr. Maximowicz characterizes a remarkable new Japanese genus, *Ellisiophyllum* (so named from the likeness of the leaves to those of *Ellisia*) which is intermediate between *Hydrophyllacea* and *Polomoniaceæ.* The habit, dicarpillary ovary hirsute at apex, and imbricated petals are suggestive of the former order; but the undivided style, central placentation, and especially the mucilaginous seed-coat, place it rather in the latter.

Dr. Maximowicz, moreover, has ascertained that our *Euodia ramiflora* is Thunberg's *Orixa Japonica*, of which only male flowers were known; and he restores that genus, referring it to the neighborhood of *Euodia.* A. G.

8. *Form and Sculpture of Seeds.*—Prof. Lange of Copenhagen has published, in *Botanisk Tidsskrift*, 1870 (in Danish) an interesting paper upon this subject, which, as botanists know, often furnishes excellent characters to distinguish otherwise similar species. He treats here of *Pyrolaceæ*, *Droseraceæ*, *Cerastium*, and especially of *Pedicularis*, with illustrations. In two plates, filled with beautiful colored figures, the seeds of 25 species of *Pedicularis* are strikingly depicted. A. G.

9. *Hypocotyledonary Gemmation* is of uncommon occurrence. My attention has been called, by Mr. Guerineau, the gardener of the Cambridge Botanic Garden, to a remarkable instance, which occurs in all our seedlings of *Delphinium nudicaule*, the unique red or red-and-yellow-flowered species of California. As this species is now in European cultivation, and a probable variety of it, *D. Cardinale* was raised and figured in England several years ago, the peculiarity in question is likely to have been noted; but I have seen no account of it. In germination, the slender radicle elevates a pair of well-formed ovate cotyledons in the usual way. These acquire full development; but no plumule appears between them; consequently the primary axis is here arrested. Soon a nassiform thickening is formed underground at the junction of the lower end of the radicle with the true root: from this is produced a slender-petaled 3-lobed leaf, which comes up by the side of the primary plantlet; soon a second leaf appears, and so on, setting up the permanent axis of the plant from a bud which thus originates from the very base of a well-developed radicle, if not from the root itself. A. G.

III. ASTRONOMY.

1. *A remarkable Meteor;* by R. H. THURSTON, U. S. N. (Communicated.)—While standing on the deck of the steamer "Electra," last evening, *en route* from Providence to New York, I was startled by a sudden flash of bright blue light which illuminated the whole heavens and was instantaneously succeeded by an equally intense red flash which again gave place to blue. Turning suddenly, I saw a falling meteor, which was, so far as my knowledge extends, unique.

It exhibited a nucleus of blue, with a long flame-like train also blue in color except on the south side where a portion, equal to perhaps one-third of the whole, was of a brilliant red.

The height of the meteor, at disappearance, was about 29° above the horizon, its bearing nearly due east from Watch Hill Light, and the time, at that place, not far from 9:15 P. M. It was about 25′ in length, and 5′ in width, moving directly downward.

Stevens' Institute of Technology, Hoboken, N. J., June 15th, 1871.

IV. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *On the influence of a covering of Snow on Climate;* by A. WOJEIKOF, Member of the Imp. Russ. Geogr. Society. (Communicated).—The influence of a layer of snow, resting on the earth's surface in the colder portions of the earth during winter, has, to my knowledge, never been considered in its general bearing on the climate and the conditions of the population living in these countries.

The first and most apparent influence of snow is the protection it affords to our crops from the cold of winter. Where the snow-mantle appears regularly, winter-crops are always sure, be the cold ever so intense. In the steppes of south and east Russia, where little snow falls in winter, and this small quantity is often blown away by the strong winds, winter crops are scarcely attempted at all. On the northern coasts of the Black Sea, summer wheat and Indian corn are very good, but winter wheat is a precarious crop, while to the north, in Podolia, it is the principal crop. There the forests afford a protection against the wind, the snow falls more copiously and cannot be blown away.

As a bad conductor of heat, the snow isolates the warmer soil from the cold air above, and there is no doubt that it renders also the winter cold more intense, as the air cannot receive heat from below. In countries where the snow-covering is not permanent, as Western Europe, this influence of snow is well known, and people expect great cold where a layer of snow has fallen and the sky clears. In countries where snow usually lies the whole winter, as Russia and the northern parts of America, this is not generally understood, and in Russia people say it is colder without snow than with it. This feeling is quite natural. The first frosts of autumn are more severely felt because the human body is not accustomed to them, and also because the air is drier than with snow, and a cold, dry wind is more severely felt than a cold moist one.

The great relative humidity of the air is a most important feature of the countries covered with snow in winter. It is as easy to account for it as for the humidity of an island in the middle of the ocean or of a place situated in an extensive swamp-tract. The wind may come from every side; it has always to pass over a large evaporating surface, and absorbs moisture if it was originally dry. In countries where cold strong winds predominate, as in the greater part of N. America and Eastern Asia, this will be less the case, as the winds, rapidly passing over the land, have not the time for absorbing much moisture, and the dryness of the air in the United States is felt by Europeans going there. But in countries situated like Europe and Western Asia, where the cold winds are usually weak, and only the warm southerly winds strong, the air will be always nearly saturated, when the soil has a snow-covering, as the cold winds, in their slow progress, have the time for absorbing moisture. This feature of climate is extremely important in the examination of storms. It was one of the chief merits of Espy to have pointed out the importance of vapor in the origin and progress of storms, and this is now generally admitted. If a storm is signalized and the beginning of its path stated, it is important to know the quantity of vapor disseminated in the countries where it is likely to pass, and the quantity which may be expected to be condensed as rain and snow. Now, the lower the temperature falls, the more uncertain are observations of the psychrometer, and I am of the opinion that it is not a sure guide below the freezing-point. This stated, it is very important to have some general idea as to the quantity of vapor over the cold spaces of the earth's surface. Now in countries situated like Europe, relative humidity will scarcely fall below 75–80° so long as the earth is covered with snow, so that the quantity of vapor in the air of these regions may be very nearly known if we know the temperature. In an examination of the barometric range in European Russia and Siberia, some time ago, I have stated that not only the pressure of the air rises in winter as we advance from the western coast of Europe into the interior of the continent, but the barometric minima rise even more, so that for example, in Nertschinsk, in Eastern Siberia, the middle barometric minima of January, reduced to the sea-level, are 30·23 in., and the lowest pressure happening in 17 years in this month was equal to 29·93. If we consider that at this place the temperature never rises above 14° F. in January, the effect of cold and small quantity of vapor in the air, in arresting the progress of storms in winter will be clearly seen. In European Russia the barometric minima are lower in winter than in the other seasons. This shows that the storms of the Atlantic take their course over our country. Speaking generally, the path of storms is from N.W. to S.E. in winter, because they cannot advance in an eastward direction as they began, being arrested by the cold. The colder the temperature is, the sooner the storms must turn to the southward, and this will be much more the case in January than in November and March, when the storms of Europe sometimes advance into the interior of Siberia.

Another feature of the snow is that of arresting the progress of temperature above the freezing-point so long as it lies. In rising above, the heat is employed in melting the snow, or in the language of the mechanical theory of heat, it is transformed into work. We have some striking facts of this kind in Russia. For example, Barnaul, in Western Siberia, has a winter temperature lower than St. Petersburg, by nearly 18° F. Yet the thermometer sometimes rises as high as in this last place in winter, because Barnaul has the Kirghi-steppes to the southwest. As they are seldom covered with snow, warm winds can pass across them and without losing their heat, while before arriving at St. Petersburg, they must lose much of their heat in melting the snow over an extensive track. The result is, that seldom a winter month passes without temperatures above freezing-point, but in January and February the thermometer does not rise above 39°, while at Barnaul a temperature of 42° may occur at that time, (for example on the 4th, 5th and 6th of February, 1855).

I have mentioned already the effect of the snow in checking the rise of temperature, and employing more abundant heat in melting. This is most felt in spring, and lowers much the temperature of this time of the year, as for example, while in Central Europe, at some distance of the sea, April has nearly the same temperature as October, in the same latitude; in Russia the warmth of the sun's rays cannot raise the temperature of the air so much, and April is generally 4° F. colder than October, while May has the same temperature as September. As soon as the snow is melted our climate assumes its true continental character. In more northern parts of Russia it is May which stays behind September; as for example, at Archangel, Berezoe and even Yakutsk in one of the most continental climates of our planet in this last place May is more than 3° colder than September, while March is 13½° *warmer* than November.

I must now state a last point, the influence of forests in equalizing the layer of snow and giving to it all its beneficial effects. Without the forests a great mass of snow is often a check to all communication, as for example, at this moment in South Russia, where most of the railways are stopped. The unusually great mass of snow is blown in all directions by the wind, unimpeded by trees, as some of these places were always steppes, in others man was too short-sighted to let the trees stand. The effect of the melting of snow on the rising of rivers will be quite different in a wooded and a bare country. In the first the snow will lie sometimes a month longer than in the last, and accordingly the floods of the rivers will be longer continued but less high and devastating. Every one who has inhabited the country will be struck by this fact and its bearing on the climate and the well-being of the population all around. Generally speaking, as I have stated, the effects of a layer of snow are beneficent to man. The proportion of the crops is of enormous economical worth. The greater moisture of the air is also good, and even the cold of spring, caused by the melting of snow, has its good side. The too rapid advance of vegetation in early spring is checked by it, and protracted to a time when the vegetables have less to fear from night frosts. Northern Europe, for example, suffers much less from this curse than the south, where the returns of cold in spring cause great damage every year. Only two serious effects are sometimes felt, the interruption of communication in snow storms and the great floods of spring. But both of these drawbacks can be avoided by the foresight of man, as forests arrest the progress of winds and cause a slow melting in spring, so as to store a great quantity of water to supply our rivers.

St. Petersburg, 20th February, 1871.

2. *Scientific Expedition from Williams College.*—The scientific expedition from Williams College, consisting of five members of the present senior class, under the charge of H. M. Myers, which left the States last November for the purpose of making explorations and collections in Central America, returned from that country in March, having successfully accomplished the objects proposed. The party spent some time upon the elevated plain of Comayagua, in Spanish Honduras, where they found the climate most salubrious. One of the immediate results of the expedition is a fine addition to the cabinets of Williams College. The ornithological specimens secured, taken in connection with those added to the museums by the expedition to South America, in 1867, give the college a most valuable collection of tropical birds. Among the additions to the archæological department are two interesting statues exhumed at Corosal, in British Honduras, ninety miles south of Belize. The work upon these images, cut from limestone rock, is quite finely executed; and being still in a good state of preservation, they are valuable and interesting relics, marking the advances in civilization made prior to the occupation of the country by the Spaniards. Although the table-lands and the Pacific coast of these Central American States have been frequently visited by collectors, the low coast-lands of the northern slope have been almost entirely passed by on account of their unhealthfulness. Collections from these comparatively new fields are especially valuable; moreover, the richness of the fauna and flora offer every inducement to the naturalist. It was upon these lowlands that the Williams College party made their largest collections.

3. *Description of a Tide-Gauge for cold climates;* by John M. Batchelder, of Cambridge, Mass.—This instrument is intended for registering the height of the tide at stations where the float and box commonly used are liable to be obstructed by ice.

A strong iron tube, about four inches in diameter, is firmly bolted to a wharf or pile. It is open at the top, and has at the lower end a nipple to which an India-rubber bag is fastened,—the length of the tube being sufficient to allow the elastic bag to be always submerged at the lowest stage of the tide.

The bag is supported by a suitable shelf, or cage, and is filled with glycerine, which is poured in at the top of the tube. When in this condition the glycerine rises and falls within the iron tube in proportion to the varying height and pressure of the column of water above the rubber bag, the difference in the height of the two columns being in proportion to the difference of the specific gravity of the water and the glycerine. The parts above described insure protection from floating ice, and prevent congelation within the iron tube.

A copper tube, about three inches in diameter, closed at the bottom, and open at the top, is placed within the iron tube, and floats in the glycerine: if left free it would rise and fall with the changing level of this liquid. The length of the central tube is a little greater than the whole range of the tide.

Near the upper end of the outer tube, there are three spiral springs, fixed at the top and united at the bottom by a plate or disk, from which the central copper tube is suspended. From a stem fixed to the center tube or float, and moving with it, a string or chain leads over a single pulley, and gives horizontal motion to the pencil carriage of the recording apparatus.

The distance that the central tube is to move, vertically, is adjusted to agree with the required range of the pencil upon the record paper, by placing within it suitable weights.

As the glycerine falls or rises in the annular space between the iron tube and the central float, the spiral spring at the top is more or less extended, the extension being uniform on account of the cylindrical form of the float.

It is not necessary that the India-rubber bag be enclosed in a perforated box for the purpose of preventing oscillation: as it is always submerged, and the pressure upon it is equal to the weight of a column of water, having its base at the bag, and its summit at the mean level of the surface waves.

This instrument has been constructed by the United States Coast Survey, and is now in operation at the tidal station in the Boston Navy Yard.

4. *American Weather Notes;* by PLINY EARLE CHASE. (Read before the American Philosophical Society, March 3, 1871.—The signal service observations of our War Department have already shown the value both of Buys Ballot's law and of Capt. Toynbee's modification in predicting changes of wind, especially if due regard is paid to the barometric variations of the two previous days. They have also suggested the following general deductions, some of which may perhaps prove to be true only of the winter, while others seem to be explicable by natural circumstances of position and physical configuration, which must be operative at all seasons.

(1.) Winds varying like the land and sea breezes, are often traceable, especially in the lull which follows the passage of storms, to differences of temperature in the neighborhood of the great lakes, and of mountain peaks and ridges.

(2.) The wind, especially in the Southern States, often blows directly in the line of the greatest barometric gradient. But even in such cases, after a few hours continuance, it tends toward the azimuth indicated by Buys Ballot's law.

(3.) The isobaric lines are, therefore, often of less relative importance than the gradients in forming forecasts.

(4.) Long ridges of high barometer, as observed by Espy and others, with adjacent troughs of low barometer, often traverse the continent, sometimes with slight deflection, sometimes having a semi-circular, circular, or elliptical curvature, with a diameter of three thousand miles or more. Such ridges usually have a steeper declivity and stronger winds on their northerly and easterly than on their southerly and westerly sides.

(5.) Currents with an anti-cyclonic tendency, controlled by areas of high barometer, are notably common. Reversals of wind, as from N.E. to S.W., are, therefore, frequent after the passage of an anti-cyclonic ridge or center, as well as after the passage of a cyclone.

(6.) Our recent storms have been anti-cyclonic, and there seems some reason for supposing that anti-cyclones are the usual "weather-breeders," even of such of our land storms as become more or less cyclonic after they are fully developed.

(7.) The precipitation of vapor of course gives rise to local cyclones, which, however, may be easily and speedily overborne by the grand anti-cyclonic whirls of a half million miles or more in area.

(8.) These and other peculiarities, point to a probable origin of storms in the blending of polar and equatorial currents, near the latitudes at which the general tendency of the winds changes its direction.

(9.) Mr. Scott has observed that when polar (E.) currents are blowing at the North, and equatorial (W.) currents at the South, a serious barometrical disturbance, frequently resulting in a gale, generally soon follows; but when the polar current is at the South and the Equatorial at the North there appears to be no law of sequence. The latter condition, with us, seems often indicative of approaching fair weather, especially if northerly or easterly are separated from southerly or westerly winds by a ridge of high barometer.

(10.) If the progress of a northerly or easterly current toward the equator is impeded by an intervening southerly or westerly current, the disturbance not only speedily follows, as indicated by Mr. Scott, but it is also, commonly, like most showers, S.E. storms, and other marked cyclonic commotions, of briefer duration than those which are primarily anti-cyclonic.

5. *European and American Rain-falls;* by PLINY EARLE CHASE. (Read before the American Philosophical Society, March 3, 1871.)—There is still a lingering skepticism on the part of some meteorologists, regarding the moon's influence on the weather, a skepticism which is perhaps owing to the apparent want of agreement between observations at different places. There is, however, no good reason for expecting such accurate correspondence as is sometimes deemed essential. Dr. Emerson (Proc. A. P. S., xi, 518) has communicated to the Society his early observation upon the reversal of the European Barometric prognostics on this side of the Atlantic. Mr. Blodget (Climatology, pp. 221–237) has pointed out various climatologic contrasts, and Mr. Scott, the Director of the British Meteorological Office, has noticed an opposition between the solar (or temperature) rain-falls in Western Europe and Eastern America, analogous to that which I have indicated in the lunar rain-falls. The confirmation thus afforded to the results of my previous investigations, strengthens the presumption that, in our Atlantic States, signs of fair weather may be most confidently trusted during the ten days preceding, signs of rain during the eight days following, full moon.

In order to make a comparison between stations of similar latitude, I obtained from the "Observatorio do Infante D. Luiz," a record of the quarterly rains at Lisbon for sixteen years, which I have embodied, together with the observations at Pennsylvania Hospital for the same period, in the following tables. The measurements are given in millimeters.

I.—*Quarterly Rain-fall at Lisbon.*

Years.	Winter.	Spring.	Summer.	Autumn.	Total
1855	280·3	272·7	15·4	362·5	930·9
1856	513·4	800·7	8·5	90·3	912·9
1857	267·8	152·2	67·9	324·4	812·3
1858	224·2	113·2	7·1	567·6	912·1
1859	128·0	201·8	71·6	306·9	708·3
1860	210·9	122·4	39·6	187·3	560·2
1861	501·5	154·3	14·6	311·4	981·8
1862	364·4	282·9	6·6	176·9	830·8
1863	181·8	196·6	64·8	101·6	544·7
1864	155·3	282·2	33·9	363·5	834·9
1865	371·6	159·2	24·4	487·2	1042·4
1866	214·7	365·3	14·6	82·3	676·9
1867	197·2	216·2	13·6	172·1	599·1
1868	162·9	76·9	38·0	279·4	557·2
1869	323·2	158·5	3·1	66·0	550·9
1870	305·7	111·6	21·9	160·3	599·5
Mean	275·2	197·9	27·9	252·5	753·4

II.—*Quarterly Rain-fall at Philadelphia.*

Years.	Winter.	Spring.	Summer.	Autumn.	Total.
1855	193·0	169·9	435·4	257·8	1056·1
1856	284·5	211·8	241·3	187·5	925·1
1857	184·4	359·9	482·6	133·4	1160·3
1858	264·9	272·8	274·1	227·1	1038·9
1859	376·7	376·9	376·4	371·6	1501·6
1860	240·3	229·6	311·7	342·9	1124·5
1861	269·8	362·5	243·3	332·0	1207·6
1862	292·6	254·5	263·1	343·9	1154·1
1863	280·7	442·0	297·4	153·4	1173·5
1864	174·8	448·3	204·2	327·9	1155·3
1865	370·1	374·7	291·9	380·3	1416·9
1866	390·4	247·9	194·6	370·9	1203·8
1867	230·1	370·6	742·5	228·1	1571·3
1868	225·3	401·3	268·0	404·6	1299·2
1869	318·5	296·2	247·7	337·8	1200·2
1870	297·7	404·9	303·8	195·8	1202·2
Mean	274·6	326·5	323·6	287·2	1211·9

It appears, therefore, that the heaviest rain-falls at Lisbon and the lightest at Philadelphia, are usually in the Autumn and Winter semester; the heaviest at Philadelphia and the lightest at Lisbon, in the Spring and Summer. In ten years out of the sixteen, when the rain-fall of the entire year was above the average at one station, it was below the average at the other.

6. *Discovery of the Animal of the Spongiadæ confirmed;* By H. J. Carter, F.R.S. &c. (Ann. Mag. N. H. IV, vii, 445). Just a line to tell you what you will be glad to learn, viz. that I have confirmed all that Prof. James-Clark, of Boston, has stated about the sponge-cell, and much more too.

It is, after all, only what was published and illustrated in the 'Annals' in 1857. Indeed I am astonished now at the accuracy and detail of that paper ("Ultimate Structure of Spongilla," &c.), now *all* confirmed by an examination of a *marine* calcareous sponge.

I have not only fed the sponge with indigo, and examined all at the moment, but the sponge so fed was put into spirit directly afterward, and *now* shows all the cells (monociliated) with the *cilium attached and the indigo still in the cells.*

This, I think, will break down Häckel's hypothesis, which is as imaginative and incorrect as it is beautiful.

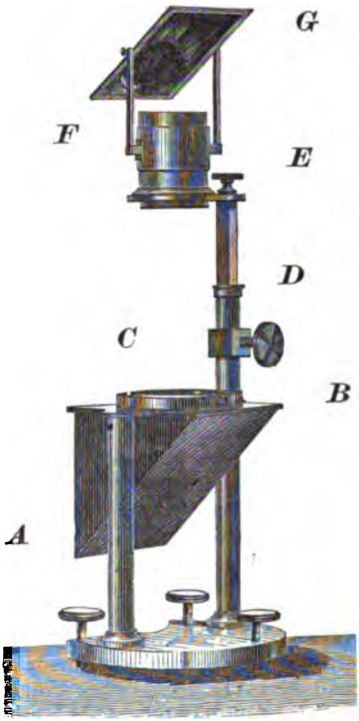
His "Magosphæra," too, is figured in the 'Annals' (1856), and described *in extenso* as the amœboid cell which inhabits the mucus of the cells or internodes of the Bombay great *Nitella.*

But there are no people in England, if on the Continent, who seem to be able to show this, if even they be cognizant of it.

Ex oriente lux used to be the old phrase; the light is now being *reflected* back from America. It is from there that we must expect novelties now.

"The Cottage," Budleigh-Salterton, May 22, 1871.

7. *A new attachment for the Lantern.*—It is often desirable to throw upon a screen the images of objects which must be preserved in a horizontal position; such for example as liquids, or solids immersed in liquids. Various devices have been tried for securing this end: all of them more or less imperfect. Recently, however, President Morton, of the Stevens Technological Institute at Hoboken, has devised a form of apparatus for this purpose which is quite simple and ingenious, and which answers its purpose admirably. This "vertical lantern" as he calls it, is shown in the accompanying figure. It is to be placed in front of the ordinary lantern-box, the condenser being composed of three lenses; the first two of these being of such a curve as to give, with the light about two inches from the nearer one, a practically parallel beam. This beam enters the apparatus at A, is received upon a mirror inclined 45°, which reflects it vertically through the third lens placed horizontally at C. This lens concentrates the beam upon the object glass at E, after passing which, it is reflected upon the screen by the silvered mirror FG. Though the lenses are all of them uncorrected, and the mirrors silvered on the back in the ordinary way with pure silver, yet there is no want of definition in the images produced, and the color is too slight to be appreciable by an audience. We witnessed the performance of the instrument a short time ago with great satisfaction. A glass plate, evenly covered with iron-filings, being placed above the lens C, a small magnet was laid beneath it, and the plate gently tapped with a pencil. The filings gradually arranged themselves in the well-known curves, producing finally a magnetic spectrum of great beauty. A shallow tank of water being then placed in the same position, the images of waves, ingeniously produced by puffs of air, were thrown upon the screen, and the various phenomena of interference and reflexion beautifully illustrated. Tomlinson's cohesion figures, produced by allowing drops of various essential oils to fall upon water, were also superbly demonstrated. By using thin glass plates covered with sand, Chladni's sound figures may in this way be developed upon the screen in a striking manner.



The apparatus was manufactured by Messrs. Hawkins & Wale of Hoboken. It is exceedingly creditable to them in the excellence of its construction and finish. G. F. B.

8. *Report on Barracks and Hospitals, with descriptions of Military Posts.* 4to, pp. 494.—Under the modest heading of "Circular No. 4," the Surgeon General's office of the U. S. War Department at Washington has issued a valuable document with the above title, containing a great amount of valuable information respecting distant outposts but little known, geographical, topographical, meteorological, sanitary, &c.

In an appendix are "Reports on Examination of Air in Barrack rooms," giving the results of chemical analysis of the air at night in barracks occupied by sleeping soldiers. Assistant Surgeon V. B. Hubbard reports four analyses of air from the apartments of the U. S. Military Academy at West Point, N. Y., made by the Captain and his assistant, which we have arranged in a tabular form for convenience of comparison. B. S.

Tabular Statement of four Analyses of Air in Military Barracks, made by Capt. Lorenzo Louvain, assisted by Lieut. John Pitman, and reported by Surgeon V. B. Hubbard.

Experiment.	Time of observation.	Tempt. Fh.	Apartment.	Contents.		Estimation of carbonic acid.		Estimation organic matter.		Superficial area of door & windo's open at the time in feet.
				Men.	Cubic feet of air.	Volume of air examined in c. c.	Volumes of CO_2 found in 10,000 vols.	Vol. of air examined in c. c.	Organic in 1000 c. c. of air.	
1	1.30 A. M., July 22, '70.	81°	Artillery barrack.	19	13,016·25	3700	9·58	34·091	·00440	131·75
2	3 A. M., July 22, '70.	78°	Cavalry barrack.	16	16,803·36	4340	9·30	34·092	·00292	111
3	2 A. M., July 26, '70.	85°	Engineer barrack.	9	6,296	----	9·37	----	·00343	63
4	2 A. M., July 28, '70.	77°	Cadet hospital.	4	4,480	----	5·68 5·52	----	·00187	73·35

9. *Captain Hall's Arctic Expedition.*—The Polaris, the vessel for the Arctic Expedition under Captain Hall, is now in New York (June 15), at the Navy Yard in Brooklyn, where she will remain ten days, or until ready to start northward. She will take in supplies to last to Disco in Greenland, where she will await the arrival of the storeship Supply, with additional provisions. Captain Hall contemplates an absence of two years and a half, and if results warrant, the voyage may be still farther prolonged. From Disco the expedition will proceed to Uppernavik or Tissonack, the most northern settlement of Greenland, where gangs of dogs will be obtained. The Polaris may have to winter in Jones' Sound, the latitude 76°N., but if possible will be pushed on to 80°N. Early in April, 1872, the journey over the ice toward the Pole will be begun. Hall asserts that if Ellesmere Land, which reaches from Jones' Sound northward, extends upward to the Pole, he is confident of reaching the great object of his destination in at least 100 days from the time he leaves the ship with his boats and sledding party. Should the land and ice termimate in an open Polar sea, his boats will be used on that as yet mythical sheet of water to complete his discoveries, precisely in the same manner as they will be employed in transporting the party from

one flöe to the other whilst among the field ice. The chief of the scientific corps attached to the expedition is Dr. Emil Bissels, who was a member of the recent Prussian expedition to the North Pole. He is a young man with a high reputation as a scientific student, and is a graduate of the famous University of Heidelberg.

Besides Capt. Hall and Dr. Bissels, quite prominent characters are the sailing-master, Capt. O. S. Buddington, who has had thirty-two years' experience as an Arctic navigator, Mr. Hubbard C. Chester, of Noank, Conn., the first officer, and Mr. William Morton, who is said to have discovered the open Polar Sea while on the first Grinnell Expedition, who goes out as the second officer. Sergt. Meyer, of the United States Signal Corps, has charge of the meteorological department. R. W. D. Bryan is astronomer.

Two of the most interesting individuals who accompany the expedition, are the Esquimaux man and woman, who have been with Capt. Hall since his first essay in Arctic explorations.—*New York Times*, June 15.

10. *The so-called "Cardiff Giant."*—It will be remembered that, two or three years since, a considerable excitement was created by the alleged accidental discovery upon the farm of a Mr. Newell, near the city of Syracuse in the State of New York, of a human figure of gigantic proportions, which was exposed during an excavation undertaken by the owner with the avowed purpose of digging a well for the supply of water to his cattle. The obvious folly of excavating for a well in the bed of a stream of water was commented on at the time and was not easily explained away: The popular appetite for marvels was, however, adroitly quickened by the story first of a "fossil man," of pre-historic age; for who did not believe that "there were giants in those times?" The absurdity of such a theory soon compelled the milder statement that while the recumbent giant was of acknowledged human origin, it was unquestionably of an unknown but very high antiquity, and hence must possess great archæological interest. With this hypothesis the so-called "Cardiff Giant" commenced his tour of exhibition, after thousands of curious spectators had visited him in his resting place as he lay exposed in the excavation upon the Newell farm: and for a time multitudes thronged the places in various cities where this supposed relic of an earlier age was to be seen. We have lately had the matter brought home to our own doors through a visit of this venerable personage to New Haven, and although we had supposed the fraud had long since ceased to be capable of exciting more than a feeling of contempt, mingled with curiosity to see by what means the delusion was produced, we have been surprised at the facility with which people, otherwise sensible, give credit to the greatest absurdities, even after the "humbug" had been fully exposed. We think therefore it is worth while to record very briefly the real history of this sham, that it may find its place in the already large catalogue of popular delusions. We suppress names, but give the main facts as we have ascertained them from an in-

telligent witness who was cognizant of the origin and progress of the statue.

The block of gypsum, from which the Cardiff Giant was carved, was quarried near Fort Dodge, in Iowa, where there is an inexhaustible supply of massive gypsum of Mesozoic age.* It was transported to Chicago, in Illinois, where it was placed in the workshop of Mr. Burckhardt, a well-known marble-worker of that city, who contracted with the originators of the scheme for a not very considerable sum of money, to produce a gigantic recumbent figure of a man. His position, resting with the left arm under the body, the right arm thrown across the body over the pelvis, and with the legs slightly flexed at the knees, was measurably a necessity of the form of the block of stone at the artist's command. This figure was first modeled in clay by or under the direction of Mr. Burckhardt, and was then transferred to the stone. Our informant states that he saw the figure more than once during its preparation. The appearance of age was given partly by treating the surface with acids to remove the tool marks and the raw look of a recently tooled surface, and this effect was subsequently heightened by the grime and soil of a seven months' interment. Thus prepared, the newly-made antique was transported by rail to a point near the Newell farm, and thence by teams to the farm itself, where, by the aid of a body of work people, brought from a distance, it was placed in its resting place, near the bed of a small stream. Those engaged in the work of removal and interment were taken away furtively, and thus no one at or near Syracuse but those engaged in the speculation knew of its existence. By a singular accident, an eye-witness to its making in the Chicago work-shop happened to be in Syracuse at the time its discovery was announced, and, visiting the Newell farm with the crowd of curious spectators, was surprised to see there his old acquaintance half buried in the earth. We have taken pains to verify this statement, and are promised at an early day a detailed statement from the work shop of Mr. Burckhardt of its entire history, which we may take another occasion to publish. B. S.

11. *Party of Exploration under Dr. Hayden.*—Dr. Hayden and party (as a letter from him informs us) were at Ogden, Utah, on June 8th. The party comprises thirty-two men (including an astronomer, topographical engineer, etc.), five wagons, two ambulances, forty-eight mules and horses. He proposes to connect with the belt under exploration by Clarence King, and then spend the remainder of the season about the sources of the Yellow Stone and Missouri rivers. He has a boat and sounding apparatus for making a complete survey of the Yellow Stone, etc. A company of cavalry is ordered as an escort from Fort Ellis. He expects to return to Washington about the 1st of November. Congress made an appropriation of $40,000 for the explorations of the season.

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* See Dr. White's report on the Geology of Iowa, vol. ii, p. 299.

12. *Survey of the Great Lakes.*—We take the following notes on this survey from Harper's Weekly of June 10th, a periodical which has in each number one or two columns of recent scientific intelligence furnished by a correspondent who is a man of thorough science, and in the way of knowing what is doing in science.

"Among the United States government explorations to be prosecuted during the present year, we should not omit to mention that of the Lake Survey under the Engineer Bureau. This work has been in progress for a number of years, and in the reliability of the observation and the beauty of the maps published occupies the very first rank. The work is at present under the charge of General C. B. Comstock, and will be carried on in several localities simultaneously. The survey of Lake St. Clair, which was nearly finished last year, will be completed the present season; and the party, on finishing it, will then proceed to the St. Lawrence River, in the neighborhood of Ogdensburg, and there carry on their labors. Both shores of Lake Michigan will be surveyed during the season, commencing at Sheboygan on the eastern shore, and at a point north of Grand Haven on the western. It is expected that the whole will be completed as far south as Kenosha before operations are interrupted for the winter. Triangulations will be conducted along Lake Michigan between Green Bay and Milwaukee. In addition to the hydrographical and surveying work prosecuted by these parties, great attention is paid to securing reliable data in regard to the meteorology of the country, with the special view of determining the average conditions of rain-fall and other phenomena.

"The data already collected have been of great value, and have done much toward supplying accurate information."

13. *Geological Survey of Canada:* Alfred R. C. Selwyn, *Director.*—Report of Progress from 1866 to 1869. 476 pages 8vo. Accompanied by Geological and Topographical Maps. (Dawson Bros., Montreal; B. Westermann & Co., N. York).—This volume contains a report of Sir Wm. E. Logan on a part of the Pictou coal-field, 50 pages; of E. Hartley on a part of the same coal-field, 52 pp.; of R. Bell, on the Manitoulin Islands, 9 pp.; of J. Richardson, on the South Shore below Quebec, 23 pp.; of H. G. Vennor, on Hastings Co., 28 pp.; of C. Robb, on a part of N. Brunswick, 27 pp.; of T. Sterry Hunt, on the Goderich Salt Region and Notes on Iron and Iron Ores, 94 pp.; of J. Richardson for 1869, 6 pp.; of R. Bell, on Lakes Superior and Nipigon, 52 pp.; of E. Hartley, on Pictou coals and Iron ores, and on Springhill Coal, 82 pp.; with an appendix containing a list of plants collected in the Manitoulin Islands, by Dr. John Bell. The excellent maps add much to the value of this interesting volume.

14. *North Carolina Tertiary.*—Mr. Conrad states in a recent letter to one of the editors, that the fossil horse of the marl near Greenville, N. C., mentioned in this Journal, last volume, on page 468, is, according to Dr. Leidy, the *E. complicatus*, a Miocene species that lived with the *E. fraternus.* The Mastodon from Raleigh (p. 469) is the *M. Americanus*, and was from Quaternary gravel overlying the Miocene marl.

15. *Volcano of Kilauea, Hawaian Islands.*—A recent letter from Rev. T. Coan states that the crater is at present in an unusually quiet state. Even the region of the great South lake, sometimes boiling with lavas over an area half a mile broad, is wholly inactive excepting the escape of vapors from fissures. At a depth of one hundred and fifty feet in some of these fissures a red heat may be seen, but no liquid rock.

VI. MISCELLANEOUS BIBLIOGRAPHY.

1. *Smithsonian Contributions to Knowledge.* Vol. xvii. 4to, pp. 590, with 14 plates.—This volume is devoted to an elaborate memoir entitled, "*System of Consanguinity and Affinity of the Human Family;* by LEWIS H. MORGAN."—This memoir was referred to a commission consisting of Prof. J. H. McIlvaine and Prof. William H. Green of Princeton, and after certain modifications suggested by them had been made, in the method of presenting the subject, it was submitted to a special committee of the American Oriental Society, consisting of Messrs. Hadley, Trumbull and Whitney, who, after a critical examination, reported that the memoir contained a series of highly interesting facts which they believed the students of philology and ethnology, though they might not accept all the conclusions of the author, would welcome as valuable contributions to science.

2. *Manual of Geometrical and Infinitesimal Analysis;* by Prof. B. SESTINI. (Murphy & Co., Baltimore.)—In the brief space of 131 pages, the author gives a *manual* of the processes and results of Analytical Geometry and Calculus. While he does not claim to give a treatise, he briefly and lucidly develops all the important formulas of both branches of Analysis, especially the formulas reached in the study of Physical science.

A Dissertation on the Principles and Science of Geometry. By Lawrence S. Benson. New York: C. H. Phelps, publisher. 8vo.

Recherches sur la Polarization Rotatoire Magnétique des liquides, par M. le Professeur A. De La Rive. 8vo, pp. 46.

The Mineral and other Resources of the Argentine Republic. Published by special authority of the National Government, by Major J. Rickard, F.G.S. 1870. London: (Longmans & Co.)

Studien über das central Nerven-System der Wirbelthiere, by Dr. L. Stieder, of Dorpat.

Bulletin of the Museum of Comparative Zoology at Harvard College. Cambridge, Mass., vol. ii, No. 3. On the Mammals and Winter Birds of East Florida, with an examination of certain assumed specific characters in birds, and a sketch of the bird Faunæ of Eastern North America, by J. A. Allen. 450 pp. 8vo, with 5 plates.

American Journal of Microscopy, devoted to elucidation of scientific and popular Microscopy; E. M. Hale, M.D., Editor, Chicago. No. 1 of this monthly on Microscopy containing 32 pages, appeared in April last. It aims to distribute in a popular way interesting information on Microscopic objects throughout the country. Subscription price $2.00 per year, or 25 cents per number.

Introductory Text-book of Meteorology, by Alexander Buchan, M.A., F.R.S.E., Sec. of the Scottish Meteorolog. Soc. 218 pp. 12mo, with several maps. Edinburgh and London, (Wm. Blackwood & Sons). A good work.

APPENDIX.

Letter to the Editors from Dr. B. A. Gould, *Director of the Cordoba Observatory, dated Cordoba, April* 26, 1871.

When I wrote you, at the beginning of November, I felt small doubt that our Observatory would be in working order so far as mason work and carpentry were concerned, before the commencement of the New Year. The brickwork was completed at the close of November as I had anticipated; but even now as I write, the portion of the building which was first provided is not finished, although a very few days will enable me in all probability to begin the mounting of the instruments. So far as delays and interruptions of every sort are concerned, the enterprise has met with a very exceptional amount of obstacles, and only three days ago my instruments arrived from Germany after ten months of delay from war, ice, storms and quarantine.

The meridian circle and photometer are now securely housed, and, so far as I can yet judge, have suffered no essential injury. Our little library too has arrived, and I need not say with what earnestness we are looking forward to a sight of the catalogues and books of reference, now hidden within the iron-bound boxes. Should no unexpected obstacles arise, we shall be able to put up some bookcases, and unpack the boxes within the coming week.

It is now seven months since our astronomical party arrived in Cordoba, and during this long period we have been without instruments, and nearly destitute of books, notwithstanding the many precautions taken to avoid such a contingency. Fortunately I had brought with my personal effects the catalogues of Lacaille, Brisbane, Taylor and Ellery; and the catalogues published by the British Association were sent me from England. Thanks to these, I am indulging the hope that these seven months will not prove to have been spent in vain.

As intimated in my former letter, I resolved, as soon as the delays became manifest, to turn our attention to the formation of a Uranometry of the Southern sky:—in other words, to the preparation of a catalogue of all stars between the South Pole, and 10° of N. Declination, which are here visible to the naked eye, assigning to each star its estimated magnitude. This work has been now actively going on for six months, and with a degree of success which I had scarcely ventured to anticipate. The sky of Cordoba, although very far indeed from rejoicing in that eternal spring and unclouded blue which I had been led to expect, possesses when clear a wonderful transparency, and exhibits to the sharp eyes of my assistants an almost incredible number of faint stars, probably at least twice as many as can be seen in the most favorable nights at home. The lowest limit of visibility to the unaided eye, I have not yet undertaken to determine; but we see fully one-third of all the stars recorded by Lacaille as of the 7th magnitude, and we have a dozen or more of cases where Lalande has noted the star as 8th.

Our scale of magnitudes is based upon that of Argelander in his *Uranometria Nova*, and to secure as complete an accordance as possible our comparisons are made with stars observed by him within the zone comprised between 5° and 15° of N. Declination, since this zone has the same meridian altitude at Cordoba and at Bonn, and the light of the included stars is thus similarly affected by atmospheric absorption.

The establishment of standards of magnitude within this belt has been by no means the least laborious and troublesome portion of the undertaking; since no star is accepted as a standard to which the same magnitude has not been assigned by the independent estimates of four observers. The large number of stars within this type-belt, which could not be seen by Argelander in Bonn, affords an excellent measure of the transparency of the sky of Cordoba.

For constellations farther South the comparison is of course not so fair, on account of their superior altitude here, still you may form some idea of the work in hand when I tell you that in *Orion* we have twice the number of stars given by Argelander, and that in *Canis Major*, the whole of which is visible at Bonn, though to be sure its Southern boundary has only an altitude of a little more than 6¼°, we have 200 stars, while Argelander saw but 39.

A good deal more than half the work is now done; perhaps two-thirds of the hemisphere have been pretty well scrutinized, and the work of reducing the stars places to the mean equinox adopted is very well advanced. The total number of stars recorded thus far is about 4100, exclusive of those observed in the type-belt.

The delays of our instruments and of the Observatory building, though in themselves vexatious, have thus been compensated by the opportunity of preparing the Uranometry which ought to be essentially completed by the first of October, unless this should in its turn be too much delayed by the new work soon to be undertaken, in conformity with my original plan. An essential feature of my present scheme for the Uranometry consists in careful measurements of the magnitudes of stars above the 4th magnitude, and for these, of course, the greater part of a year must elapse after the photometer shall have been put in order by repairing the small damages which it has suffered on the voyage.

Our observations have greatly impressed me with the thoroughness and excellence with which Lacaille accomplished his work at the Cape of Good Hope with the poor means at his disposal nearly a century and a quarter ago. This devoted astronomer, having only a telescope half an inch in aperture and magnifying 8 times, observed, within a period of 11 months from the commencement of the series, something more than 100 zones, covering the region South of the Tropic of Capricorn. Like those of sundry other astronomers, most of his observations remained unreduced for the greater part of a century; but the catalogue computed from these observations at the expense of the British Association for the advancement of Science, and published by that body in 1847, contains the places of nearly 10,000 stars, which experience shows to have been determined with a degree of precision decidedly greater than he himself had supposed. And although his zones overlapped but little at their margins, so that only a small proportion of the sky was observed more than once, the scrutiny must have been extremely thorough for such stars as his little telescope would make manifest. The number of stars south of the Tropic, which we have detected, and which are not in his catalogue, is relatively quite insignificant, so that the task of identification has been by far less difficult than I was prepared to expect.

The recent publication, by Admiral Sands of the Washington Observatory, of Gilliss's Southern Catalogue of about 2000 stars affords a valuable supplement to Lacaille, since it gives observations of many stars for which there seemed reason to suspect errors in Lacaille's determination. And if, as recent letters from home give reason to hope, this is to be followed by Gilliss's splendid series of zone observations, comprising some 23,000 stars within 24° of the South Pole, observed in Chile twenty years ago, the Southern observer will receive a truly effective assistance in his labors. Indeed, after so long a period of apparent inaction, a new day seems dawning for stellar astronomy in the Southern Hemisphere. The careful and abundant observations of Maclear at the Cape of Good Hope, which have been accumulating for a quarter-century are now to be reduced and catalogued by his energetic successor Mr. Stone; and from the shores of Australia we are already receiving, thanks to the industry and ability of Mr. Ellery, an annual instalment of meridian observations, which may fairly challenge comparison with the most exact which are furnished by the first observatories of the Northern Hemisphere.

The difficult question of the Southern Constellations is of course now forcing itself in an especial manner upon my attention, in connection with the Uranometry. What constellations to retain, and what to disregard among the various suggestions of various astronomers, has been a less difficult question than the assignment of boundaries or the adoption of a definite and consistent notation from out the chaos which rules in sundry portions of the Southern sky. These matters, comparatively insignificant in many relations, acquire a supreme importance when questions of nomenclature become prominent, as in the work now in hand. Bayer, whose authority is accepted as law for the notation of Northern stars, named many of the Southern stars simply from descriptions given him by Southern navigators. Lacaille was either unaware of Bayer's notation or gave no heed to it, and later astronomers have increased rather than diminished the confusion. The difficulties were ably pointed out by the younger Herschel, but such few remedies as he suggested have tended rather to aggravate the evil, as for instance, in the case of *Argo Navis*, where the practical and effective suggestion, adopted by Baily, in the three catalogues of the British Association, of dividing this huge and unwieldy constellation into four smaller ones corresponding to the parts of the Ship, as indicated by Lacaille, is more than counterbalanced by the other recommendation, likewise adopted by Baily, that so far as the Greek alphabet is used, the original constellation be retained, while each of the four sub-constellations has its own special nomenclature in the two series of letters of the Latin alphabet. Nor are the three catalogues edited by Baily for the British Association altogether accordant as regards either the constellation-boundaries, or the notation of the stars, notwithstanding his efforts to furnish some relief for the existing confusion. The same Greek letter occurs twice in the same constellation in more than one instance in these catalogues, while other letters are entirely wanting.

Let me give you an illustration of the confusion encountered in a study of prominent Southern stars. Take the constellation *Telescopium*, one which has every reasonable claim to be accepted and retained. Here B is in fact η *Sagittarii*, γ, η, and ο are in *Scorpius*, and σ is in *Corona Australis*. Or take *Piscis Austrinus* and follow the catalogues. Here Brisbane's ε is Baily's γ; Brisbane's η is Taylor's ο and Baily's δ; Brisbane's γ is Baily's ε, while Taylor gives it no letter. Brisbane has two κs, one being Bayer's η, while Baily assigns no letter to the other; but Bayer's κ is γ *Gruis* of Lacaille (and Baily). Brisbane's ι is Baily's (and Bayer's) μ; of Brisbane's two δs one is Baily's τ, and the other has no letter in his catalogues; Brisbane's ν is Taylor's ω, while Baily gives no letter to it; Taylor's γ, φ and ψ have no letters given to them by either Brisbane or Baily. Indeed Baily puts φ in Aquarius.

Now the application of any general rule seems out of the question. For such stars as are visible in Central Europe, Bayer's notation should assuredly be retained, yet for many stars farther South, the star actually cannot be identified with certainty to which his letters were intended to apply. Where Bayer's notation fails, Lacaille's has the next claim; yet in many instances he has employed a letter already assigned by Bayer in a more Northern portion of the same constellation. Not unfrequently too Baily has attempted to improve upon both Bayer and Lacaille, and not with the best success; yet inasmuch as every existing Southern Observatory, so far as I am aware, has been organized by some astronomer whose native tongue was English, and who has therefore depended to a greater or less extent upon the three catalogues of the British Association, this "improved" notation, like the "improved" notation of Bessel's star-constants, *a*, *b*, *c*, *d*, has found a wide adoption.

Add to this that, so far as I am aware, no attempt has been made to give precise boundaries to the several constellations, and you will see that the task of arrangement is no slight matter, when every visible star is to be assigned to some definite constellation. This implies the establishment of boundaries, and one needs but to glance at any celestial globe or atlas to convince himself that this is a process more easily spoken of than accomplished. If performed in a manner acceptable to astronomers it will find prompt adoption, and evoke order from confusion; if, however, it should fail of approval, it will but add one more chaotic influence. Any attempt at such a revision and establishment of boundaries should be restricted by certain fixed regulations, prescribed in advance, and not to be transgressed upon any pretext; if such can be judiciously laid down, and yet found upon trial not to be incompatible with an arrangement of boundaries easy of recognition and of description, I see no reason to doubt their glad reception by astronomers, as a simple means for substituting for the existing confusion a well ordered and unmistakeable system.

Notwithstanding some misgivings, I am at present occupied in the attempt to arrange the Southern constellations in such a way that the changes may be regarded by astronomers as only for the better.

During the last week we have unpacked the equatorial, and have mounted its bed-plate upon a pier of white marble, from the Sierra four leagues away. The instruments appear to have arrived in perfect condition, and as soon as the dome is made rain-tight, and the interior of the building plastered, I shall proceed to the mounting of the telescope, for which all needful preparations are already made. That the shutters should be rain-tight, is a much more essential condition than I had been led to suppose, for the summer rains here are sudden and vehement. The theory of an eternal summer is thoroughly disposed of; for during the last three months we have not had a dozen perfectly clear nights, the sky being overclouded with almost perpetual nimbus, although very little rain has fallen This, I am informed, is the ordinary character of the weather during a considerable part of March and April, the autumn being ushered by a long cloudy season. I wrote you before that I had known no rain here without abundant thunder and lightning. During this long cloudy season a light misty rain has several times occurred without electrical manifestations, although as regards regular showers or copious rains, I have seen no reason to change my earlier impression. The rainless season is now said to be close at hand. It will assuredly find with us a cordial welcome.

It is to be expected that in the course of our work we may encounter a number of variable stars sufficient to make the number in the Southern Hemisphere approximately equal to that of those already known north of the Equator. As yet however we have not followed through any very decided changes, although there is a considerable number of stars whose magnitudes, as observed by us, differ widely from those recorded by other astronomers, and which also appear to have varied during the period of our observation.

The star η *Argus*, has naturally attracted a good deal of my attention. It is at present not far from the 6½ magnitude and recognizable with great difficulty by the naked eye. In the field of my small Tolles telescope of 5 in. aperture, and 35 in. focal length, it is a conspicuous object, and prominent by its ruddy color among the cluster of which it forms a part, against the bright nebula as a background. With this telescope, the same one which I employed for observing the total eclipse of 1860, I have been examining the whole group; and have found to my astonishment that it exhibits with distinctness a considerable number of stars, which are recorded in Sir J. Herschel's catalogue of this cluster, as being of the 14th magnitude.—(*To be continued.*)

Party of Geological Exploration under Prof. O. C. MARSH.—Prof. Marsh, with a party of twelve, is about leaving for the Rocky Mountain region and the Pacific coast, to continue his investigations with reference to the Cretaceous and Tertiary vertebrates of the region. He will be absent about six months.

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ART. XI.—*Historical Notes on the Systems of Weather Telegraphy, and especially their Development in the United States;* by CLEVELAND ABBE, A.M.

THE recent establishment in our own country of a national System of Weather Reports and the general interest in this enterprise, has induced me to accede to the request of the Editor of this Journal, and to offer the following notes relating to the development of the idea of storm warnings.

It was evidently possible to study with advantage, the progress of atmospheric changes only when the telegraph lines had become widely extended over the earth's surface. It was through the public press—the daily newspaper—that it first became possible to watch the hourly progress of storms, under one's own eye, and to confirm the general laws independently deduced from the closet studies of the professional meteorologist. The first mention that I find of the systematic daily use of these daily press reports, is given by Kämtz, in his "Repertorium," wherein it appears that already in 1835, he began to collate the weather reports published in the Vossische Zeitung of Berlin. In the subsequent history of Weather Telegraphy in Europe, I first find a suggestion by John Bell, made in 1848, at the Swansea meeting of the British Association for the Advancement of Science, that in London it was already possible to receive weather reports with only a few hours' delay, from most parts of Great Britain and Europe, and that this information ought to be utilized for the study and prediction of storms. The general press reports seem to have continued to be in

Europe the only source of information regarding the impending weather, until Le Verrier first began to publish the Bulletin International. Already in 1854 he had urged the importance of systematic telegraphic weather reports, and in 1855 the Emperor Napoleon sanctioned the beginning of the undertaking: the stations from which reports were received during the first two years were confined mainly to France, but the network of stations was extended to foreign countries in 1857. In 1858 all the important cities of Europe were included, and on the 1st of January of this year began the publication of the "Bulletin International,"—previous to this the telegraphic reports had been distributed gratuitously, but only to the observers and others immediately engaged in the work. With September, 1863, began the publication in the Bulletin of the chart and the isobaric curves for Europe. During the previous six years LeVerrier had met with insurmountable obstacles to the systematic utilization of the weather reports, by disseminating predictions of storms, &c.,—but occasional warnings had been issued, and the practicability and importance of the matter had been faithfully urged by him. In this year (1863) stimulated probably by the success of Fitzroy in England, the obstacles were partly removed, and the French system of daily probabilities of weather was inaugurated. In 1865 the coöperation of the French marine was obtained, and with this year begins the series of quarterly volumes of the "Atlas Généraux des Mouvemens de l'Atmosphère." To the preface of this volume we must refer for the fullest detail of LeVerrier's undertakings.

The storm warnings issued since 1860 by Buys Ballot in the Netherlands, and those of Fitzroy (died, May, 1865), and Babington in England (Feb., 1861, to Dec., 1865), followed upon the growing success of the French system; and the recent extension of these to India and Russia, as well as the system now being organized in Australia, need but to be mentioned. The present English system in charge of the "Meteorological Committee," is in some respects very different from that established by Fitzroy: it began its publication of weather intelligence in December, 1867.

While thus practical meteorology has made brilliant progress in Europe, we cannot forget that the original impulse to this success was given by the labors of our own countrymen. Franklin* is said to have been the first who strictly defined and published the general law that the storms of our Southern States move off to the northeastward over the Middle and

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*** Earlier than Franklin must have been Lewis Evans, who, according to Hon. T. Pownal, M. P., published in 1749 at Philadelphia, the brief statement of this general law. (See Blodget's Climatology, p. 379).**

Eastern States, preceded by northeastern wind and rain, and these latter followed necessarily by low barometer and westerly winds, with clearing up weather. In this we recognize the original of the generalizations of President Jefferson and Dr. Mitchell, as published in their writings, and something a step in advance of the propositions of Lavoisier, for the study and prediction of storms. (See Atlas Généraux, 1865, p. 13).

To Sir Wm. Reid and W. C. Redfield, (this Journal, 1831) is due a clear analysis of the elements of storms and the deduction of the more general laws followed by them. To the generalizations of these authors relative to the ocean storms of the Western Atlantic, Espy (Philosophy of Storms, 1841, and Reports, 1854), and Loomis (on the Storms of 1836, 1842, &c.) added others referring to the storms of our interior, and to the origin of atmospheric disturbances. To Ferrel (the Motions of Fluids and Solids, 1856 and 1860) we owe the most complete mathematical investigations into the general and the special movements of the atmosphere.[*]

However frequently the idea may have been suggested of utilizing our knowledge by the employment of the electric telegraph, it is to Professor Henry and his assistants in the Smithsonian Institution that the credit is due of having first actually realized this suggestion.[†]

The practical utilization of the results of scientific study is well known to have been in general greatly furthered by the labors of this noble Institution, and from the very beginning Professor Henry has successfully advocated the feasibility of telegraphic storm warnings. The agitation of this subject in the United States during the years 1830–1855, may be safely presumed to have stimulated the subsequent action of the European meteorologists. It will be interesting to trace the gradual realization of the earlier suggestions of Redfield and Loomis, in the following extracts from the annual Smithsonian Reports of the respective years.

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[*] Meteorological studies were actively carried on by the Joint Committee of the American Phil. Soc. and of the Franklin Institute, from 1834 to 1838, Professor Espy being chairman, and were furthered by the Franklin Kite Club in the latter year.

[†] See Vienna Acad. Sitzungsberichte.

The first published suggestion that I have found is by the lamented Redfield; this Journal, Sept. 1846.

"In the Atlantic ports, the approach of a gale may be made known by means of the electric telegraph, which probably will soon extend from Maine to the Mississippi, &c."

The next notice and very nearly in the wording of the above, is in the Report to Prof. Henry, by Prof. Loomis. Smithsonian Report, 1847.

"When the magnetic telegraph is extended from New York to New Orleans and St. Louis, it may be made subservient to the protection of our commerce, even in the present imperfect state of our knowledge of storms, &c."

See also the "Rural New Yorker" of the following year; also the "Boston Courier" and the "Philadelphia Evening City Item," for 1848 and 1849.

1847. "The extended lines of telegraph will furnish a ready means of warning the more northern and eastern observers to be on the watch for the first appearance of an advancing storm."

1848. "As a part of the system of meteorology, it is proposed to employ, as far as our funds will permit, the magnetic telegraph in the investigation of atmospherical phenomena.... The advantage to agriculture and commerce to be derived from a knowledge of the approach of a storm by means of the telegraph, has been frequently referred to of late in the public journals; and this we think is a subject deserving the attention of the Government."

1849. "Successful applications have been made to the presidents of a number of telegraph lines to allow us at a certain period of the day the use of the wires for the transmission of meteorological intelligence ...... as soon as they [certain instruments, &c.,] are completed, the transmission of observations will commence."

[It was contemplated to constitute the telegraph operators the observers].

1850. "This map [an outline wall map] is intended to be used for presenting the successive phases of the sky over the whole country at different points of time, as far as reported."

1851. "Since the date of the last report the system particularly intended to investigate the nature of American storms immediately under the care of the Institution, has been continued and improved."

The system of weather reports thus inaugurated continued in regular operation until 1861, when the disturbed condition of the country rendered impossible its further continuance. Meanwhile however the study of these daily morning reports had led to such a knowledge of the progress of our storms, that in the Report for 1857, Prof. Henry writes:

1857. "We are indebted to the National Telegraph Line for a series of observations from New Orleans to New York and as far westward as Cincinnati, which have been published in the Evening Star of this city. We hope in the course of another year to make such an arrangement with the telegraph lines as to be able to give warnings on the eastern coast of the approach of storms, since the investigations which have been made at the Institution fully indicate the fact that as a general rule the storms of our latitude pursue a definite course."

It would seem therefore that nothing but the disturbances of the late war prevented our having had ten years ago a valuable system of practical storm warnings. Even before peace had been proclaimed, Professor Henry sought to revive the systematic daily weather reports, and in August, 1864, at the meeting of the North American Telegraph Association (see their published

Report of Proceedings), a paper was presented by Professor Baird, on behalf of the Smithsonian Institution, requesting the privilege of the use of the telegraph lines, and more especially in order to enable Professor Henry "to resume and extend the Weather Bulletin, and to give warning of important atmospheric changes to our seaboard." In response to this communication it was resolved, "That this Association recommend . . . . to pass free of charge, . . . brief meteorological reports, . . . for the use and benefit of the Institution."

On the communication of this generous response, preparations were at once made for the laborious undertaking, and the inauguration of the enterprise was fixed for the year 1865. In January of that year however occurred the disastrous fire which so seriously embarrassed the labors of the Smithsonian Institution for several following years: it became necessary to indefinitely postpone this meteorological work, which indeed had through its whole history been carried on with most limited financial means, and was quite dependent upon the liberal coöperation of the different telegraph companies.

It will thus be seen that without material aid from the Government, but through the enlightened policy of the telegraph companies, and with the assistance of the munificent bequest of James Smithson, "for the increase and diffusion of knowledge," the Smithsonian Institution, first in the world, organized a comprehensive system of telegraphic meteorology, and has thus given first to Europe and Asia, and now to the United States, that most beneficent national application of modern science, the Storm Warnings.

Having been absent from the United States in 1864–66, it so happened that I was not acquainted with the more recent plans of the Secretary of the Smithsonian as above detailed, but rather supposed that its costliness would always prevent the resumption by that Institution of this national work. In May, 1868, on taking charge of the Cincinnati Observatory, I urged in my Inaugural Report, that the practical utilization of the sciences there cultivated should be our constant care, and the desirability of storm warnings was specially indicated. This latter subject was in the same year brought by myself before the Cincinnati Chamber of Commerce, and that body at once decided to authorize me to establish a system of Reports and Predictions, at its own expense and for its special benefit.

"The Weather Bulletin of the Cincinnati Observatory" began September 1st, 1869, the previous summer having been fully occupied with preparations for this duty as well as with the labors incident to the "eclipse expedition" of the Observatory.*

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* Accompanied by seven amateur assistants, I occupied the site of old Fort Dakotah, (now Sioux Falls City), Dakotah Territory. A very complete series of

Beginning with ten stations, the number was gradually increased to thirty, from most of which the experienced correspondents of the Smithsonian Institution sent me their morning observations. The dispatches being in a condensed form, allowed me to receive the fullest details, i. e. barometer; dry and wet thermometer; direction and force of wind; weather and rain-fall; kind, amount, direction and velocity of motion of the upper and the lower clouds; and remarks. The Bulletin was published in printed form at first, and subsequently by the "Rogers Manifold Bulletin Process," appearing daily (Sundays excepted), at noon. To it was appended a brief forecast of the weather that would probably be experienced at Cincinnati during the next twenty-four hours.

This was, I believe, the first systematic attempt in the United States to make the weather reports practically useful to our commercial communities. At the expiration of the first three months' trial, and while negotiations were pending with the Western Union Telegraph Company, for its permanent continuance, I, in order to prevent a break in the series, for six months maintained the Bulletin myself, receiving the dispatches gratuitously from the telegraph employées, and publishing the reports daily, including Sundays, in the newspapers of Cincinnati. The reports indeed ceased to include barometric readings, but the number of stations was much increased, and the value of the Bulletin to the general public very frequently acknowledged. In February, 1870, Mr. Armstrong, the enterprising manager of the W. U. Tel. Office in Cincinnati, undertook the daily publication (by the Rogers Manifold Map Process) of a Weather Map for the United States, and this added very much to the value of and interest in the reports. Copies of this map were regularly sent to the telegraph offices in Chicago and New York and elsewhere, everywhere meeting with favor. In May, 1870, the publication of both Bulletin and Map was undertaken by Mr. Armstrong, and continued to be issued by him until in December, when the entire service was relinquished, in view of the daily publications of the Army Signal Office.

I had undertaken this laborious work, in the confident hope that by it a local interest would be excited in the Observatory, which might possibly lead to its being better supported by the friends of science in Cincinnati: and equally had I hoped and expected thus to contribute towards the establishment

observations was secured, but the subsequent year was incessantly occupied with very imperative labors on the Weather Bulletin and a subsequent absence from Cincinnati, so that I have as yet been utterly unable to even attempt the reduction and publication of our observations. By means of a very fine six-inch achromatic and favored by a remarkably clear atmosphere, interesting and novel observations were made upon the corona, of which a brief notice was at once communicated to the editor of the *Astronomische Nachrichten*.

of a more extended and ultimately of a national system, such as those that had long been known in Europe. To this end I, in August, 1869, in behalf of the Cincinnati Chamber of Commerce, had proposed to the Board of Trade of Chicago a general plan of coöperation by which both organizations would share in the advantages expected to result from the Weather Bulletin. That body, however, through a special committee, preferred not to engage in such an enterprise, although sensible of its feasibility, unless the Dearborn Observatory should give it the weight of its authority and name; but the other duties of Professor Safford seemed to forbid this, and I was forced to forego the advantage of such coöperation. An editorial in the Chicago Evening Journal of August 13–17, served, however, to call attention to the Cincinnati enterprise.

In November, 1869, occurred at Richmond the annual meeting of the National Board of Trade. Several of the Cincinnati delegates (and especially Mr. John A. Gano, President of the Cincinnati Chamber of Commerce) had been the hearty supporters of my Weather Bulletin, and were desirous of bringing the subject to the attention of that body. Their action was, however, anticipated by that of the Hon. C. D. Holton of Milwaukee, who presented a memorial, drawn up by the Hon. I. A. Lapham. This distinguished observer, to whom I had for some time been indebted for my daily weather report from Milwaukee, was perhaps more sanguine than myself of the prospect of immediate aid from Congress, and heartily labored to impress the importance and feasibility of storm warnings upon the attention of that body. By him was drawn up the memorial presented to Congress, Dec. 14, 1869, by Hon. H. C. Paine, and the subsequent papers printed as Miscellaneous Document 10, (41st Congress). This latter paper, as well as the chart of the storm of March, 1859, published by Professor Lapham in the Chicago Bureau, served to very generally arouse public attention. The necessity for action was heartily endorsed by prominent Boards of Trade and Commerce and by eminent scientific authorities. To Mr. Paine is due the suggestion that the conduct of the service be entrusted to the War Department, and it is interesting to notice that independently of and coincident with the labors of Professor Lapham, "papers and maps in reference to the same subject were prepared in the War Department."

Congress as well as the country seemed ready for this measure, and by unanimous consent the following joint resolution was promptly passed, receiving the President's signature on the 9th February, 1870:

"Be it resolved, &c., That the Secretary of War be, and he hereby is, authorized and required to provide for taking meteorological observations at the military stations in the interior of the continent, and at other points in the States and Territories of the United States, and for giving notice on the northern Lakes and on the sea coast by magnetic telegraph and marine signals, of the approach and force of storms."

By a general order of March 15th, Brevet Brig. Gen. Albert J. Myer, the Chief Signal Officer of the army, was charged with the duty of the execution of the preceding law, and has therefore organized in connection with the Army Signal Office, the "Division of Telegrams and Reports for the Benefit of Commerce."

Washington, May 1, 1871.

ART. XII.—*Infusorial Circuit of Generations;* by THEOD. C. HILGARD.

[Continued from page 25.]

A DIRECT *onward* evolution of Vorticella I had occasion to realize on the fetid scum cuticle of a putrescent aquarium. All the Vorticellæ which, in dense clusters, lined the under surface of that membrane, or animal pellicle, were found to *elongate* into a sort of roughish, but very hyaline, cucumber-shaped form; each "cucumber" at first crowned with a true vorticellan pitcher-mouth, mostly, however, closed and rounded over, occasionally gaping or as it were *yawning* spasmodically, at intervals only, and which finally "shut up" for good. The little glassy knobs—like so many trunk-nails—that covered the surface, grow into soft, jerking-bristles:* the mouth into the well-known mustachioed slit of barbiform *cilia;* and the wan, limpid, empty and now entirely flattened, ligulate or sandal-shaped body tears loose as a young fluttering, pallescent *Oxytricha* (*Pelionella*), or so-called "hackle-animalcule:" *darting* by the jerks of its stiffish marginal bristles, and by the constant "plying" of the long-barbed, ciliate slit effecting its slower progress. It never revolves, but often crawls; (both in contradistinction to the fleeced, revolving and vacuole-propelled "Paramecium" form.

This is probably the "short-line" development, of Oxytricha, directly from the germinal clouds or the parasite of *Chlamydococcus*, through Vorticella. I have no good figures to refer to, since even the detailed ones of Ehrenberg, in Trans. Berlin Acad.

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* In their onward development these softish bristles are indurated into "styles" (of specialists). The attentive reader will observe that on such alterations of growth alone, a great many colliding false genera and species have been formed. *Sap. sat.* We have naturally to reject all, of which the *mode* of development remains unknown, as indicating a false standpoint.

Sc., 1833, Tab. III, figs. II, III, and IV, which belong here (as well as Tab. XXIV and XXV of A. Pritchard's Hist. Inf., 1861), are too inaccurate to serve as a guide, or to be readily identifiable even by those acquainted with the real, natural object-material itself.

At first the bristles of the (tongue-shaped, flat and elongate-elliptical) Oxytricha are fluttering and tremulous; but as it feeds and rapidly increases in bulk, all the well-known characters of the complete "Oxytricha," its stiffish darting-bristles, its grumose, obscured body, irregularly replete with granular yolks, and very frequently cross-dividing, become typified. When thus cross-divided (a process well-known and abundantly figured) the front part alone retains the barbed mouth, which, from the apex, switches down like a moustache on a longitudinal slit about a quarter of the whole length. The blunt rear-part, on the contrary, separates with an incurrent angle which soon contracts into a new mouth; whereby the rear-animal takes a blunter shape (like the cotyledon of an almond, the flat side downward).

The Oxytricha is by no means, however, to be considered as an adult form, since it is never seen to exhibit a continuity as of a membrane, or of internal ducts or viscera. Neither is it seen to "copulate" or adhere lengthwise, or in any other fashion, to one another, except in the process of self-division. Nor does it readily divide by longitudinal fission, in this state. I have seen this only once. Crawling and darting by an apparatus of marginal bristles, prolonged in front and particularly in the rear, it is destitute of the "propulsive vacuoles," as found e. g. in the large "*Paramecium Aurelia;*" but, besides being studded, particularly in the rear portion, with a great number of larger and smaller granular *pellets*, its body exhibits near the middle a large, clear and granulate "germinal speck" or *nucleus*, which is often observed to swell, protruding globularly over the surface, below and above, when seen crawling, in profile.*

Occasionally it is seen to extrude, suddenly, that turgid germinal nucleus or yolk (*vitellus*), which, as in all these cases, is itself coatless, but hung around with divers jerking molecular fragments, torn loose from the parental body;—which is *ruptured on the spot*, but readily "re-cemented," as it were.

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* The transformation of the "rear-part" of Oxytricha, as given by J. Haime in Ann. Sci. Nat., Ser. 3, tom. xix, p. 109 (and represented in Carp. Micr,. p. 447 and 448), I have not been able to verify myself; it must not, however, by any means be confounded with the *encystments* (1) of Vorticella, producing wafer-like molecules; (2) of the non-pulsating, tear-shaped "Paramecium kolpoda" grub, producing free Oxytricha; nor (3) with that of the "oyster" or "porte-monnaie" grub, producing paramecium-like bodies, gregarina-fashion; nor either (4), with some large Oxytricha "currants," containing the revolving "crucible."

The larger of these coatless, granular yolks—(constituting the original *pseudo*-genus, and species "*Zooglœa Termo*" Dujard.")[*] mostly consist of two parts, viz: a general "albumen" of a granular and evidently *trabecular* texture, enclosing one or two *distinctly coated*, quite hyaline and perfectly *globular vesicles.* The latter resemble in shape a very clear white currant, as it were, by having a sharply defined circlet inscribed near one side, that is caused by a local *inversion* of contents (somewhat like the air-vesicle within a hen's egg).

These "currant"-yolks enlarge in size and soon at the (darkening) circlet, or rim of the introversion, reveal a rapid rotation and "ciliary motion;"—and, still later, a contortion and volubility of contents, really perplexing to the attentive beholder, who in vain attempts to determine its form, or at least to detect it in the moment of hatching, "anxiously wasting whole nights and half days" thereon, as Ehrenberg has expressed himself on a similar subject. At last the membrane bursts and extrudes a globe or halo of gelatine, containing a crucible-shaped body, gently moving, which, when finally set free by the rupture of that gelatinous halo, at once elastically *extruding the inverted part*, takes a shape resembling a rice-palea or the fore-wing of a thunder-fly (Thrips); traveling broad-end foremost with great velocity, and steady as an arrow. After a while a somewhat ludicrous scene ensues, when the little animal, by shedding its fissured skin or scabbard, is seen violently struggling to disentangle its large jerking bristles hidden in the *veins* of the sheath, and its small body. It thus appears like a little dwarf, frantically floundering about in a Spanish cloak, spurs and sword too large for their owner. It now represents a very small Oxytricha with comparatively very long, stout, but as yet softish bristles.

This formed the more *direct* evolution, from the Oxytricha pellet, viz: out of its circular "currant-vesicles." Its enveloping grumose mass of "trabeculated albumen," however, keeps still increasing to the appearance of a loose snow-ball, as it were; and each single trabecular joint assuming a sort of warped §-form, and a jerking spasmodic commotion, they at last tear loose singly, and escape each as a lanceolate, *warped* and finely-tailed "*Vibrio Termo* Dujard."[†] In consequence of its twisted shape, it makes its way with a vacillating archimedean motion, being constantly turned round as it is rushing onward. When about $\frac{1}{200}$ line long, it already clearly reveals the (still warped, but finally flat) *wafer*-shaped body; and the longitudinal *striæ, fringed with an undulating fleece*, as well as the oblique, ciliate mouth, which also characterize its later stages. From an oblong orbicular pouch-shape, when about $\frac{1}{80}$ of a line, it becomes round like "navy"-beans (up to $\frac{1}{50}$ of a line) only a little tapering at the upper end; the small oblique mouth being a little above the middle. The delicate longitudinal striæ all over the body—melon-fashion—give them an iridescent appearance, both under the microscope, singly, and when swarming in masses on the surface, e. g. of aquaria, or of the draining-pans of flower-stands. The striæ are apparently set with very soft *undulating threads*, resembling wool, nearly half a diameter long, in likeness of "ginned" cotton-seed. This feature is absolutely overlooked in most of the figures from Ehrenberg up to the present day; otherwise, the former's "*Paramecium Kolpoda*"* would seem to represent a few of its onward developments.

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[*] As represented by Cohn in "Nov. Act. Nat. Curios." 1854, Vol. I, Tab. XV, fig. IX. In Klob's microscopic researches on Cholera, the term is misapplied to engorged joints of dissected corruptive fibrils (or, "Oidium lactis") replete with bacterial daughter-cells.

[†] The name of "*termo*" (τερμων, a boundary-pole or stake) probably referred, originally, rather to the cylindric "battering-rams," extruded from diffluent "currant"-vesicles (or *amœba*) of the paramecian cloud-dissolution, as below detailed. The albuminous Oxytricha-pellet is pretty well represented in A. Pritchard's "A History of Infusoria," tab. XVIII, fig. 69. The indistinct §-shaped (constituent or) developing particles, however, are there technically represented by shading with cross-striæ, conveying a false impression of their shape and structure.

The body now commences to *bisect*, at first crosswise; becoming *waisted, across the mouth*, so that each half has a part of the old one. After assuming the form of an 8, they, after long struggling and toiling, bisect, often spinning out a long gelatinous thread (as of a limpid gum) and jerking each other most lustily; but after disruption, they presently round off.

In this condition, and the following, the bodies contain one larger and a great many smaller granular *pellets*,—"yolks" or "germinal specks," which I have not distinctly seen discharged. But now the surface of the water becomes clouded with such granular balls, of uniform molecules (about $\frac{1}{1500}$ line in thickness) that likewise germinate into the fragiform clouds, alluded to in connection with Vorticella, etc., and is covered with an apparently amorphous, most delicate but cohesive pellicle (as of collodion) at the superficial contact with air. All these forms, as above stated, when caught on a dry surface (e. g. by their undulating floss), instead of forming into a dry scab, suddenly become *liquid* (like fusing lead), with an immense internal commotion of parts, and bodily dissolve into such cloud-molecules. The "wool" itself becomes *quasi*-"dropsical," and each single fibril diffluent into a series of such uniform globular molecules, which at first are endowed with an independent motion, vibrio-like. Besides this, most of the encystments, moultings and yolk-extrusions take place under the isolating cover of that uniform protoplasm-membrane, which seems to exhale a sort of bituminous odor (like the fumes of burning flesh, sun-baked carrion, or the rank smell of miry river banks). Membranes, as thin but chemically homogeneous organic substances being impermeable to certain gases, while permeable to others, a good deal of physiological interest is involved in the study of this protoplasm-membrane, and its relation to the swamp-gases. The particles of the nubecula are uniformly globular.

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* Abhandl. Berlin Acad. Wiss., 1834, Tab. III, fig. 3.

After repeated *cross*-segmentations, these undulate fimbriate bodies, always revolving about the long axis (while evidently traveling onward by the action of the *ciliate mouth*) divide *lengthwise*, from below upward; thereby becoming somewhat purse or tear-shaped; the mouth being split in two, so that both stand "plying" mouth-to-mouth, while yet connected at their foreheads, as it were. These finally tear asunder by indentures, after which each has the shape of a crooked glass-tear. When more adult, and about $\frac{1}{48}$ of a line long, the internal yolks and designs have disappeared; the sarcode assumes a uniform yellowish tinge; its mouth forms deep cavities, while its front is toppling over like the hood of an Indian turnip (*Arum triphyllum*) or of a Sarracenia leaf. It now contracts to a globe and encysts. When a smooth, transparent crust is formed, gradually an inward gyration of cilia (as of an enclosed centipede) which ultimately becomes very violent, is observable; and at last the excessive fatigue of watching this tantalizing gyration may be rewarded by seeing the *inmate emerge*, either as quite a large but excessively limber, fluttering and transparent, full-size, single Oxytricha; or else several smaller, mostly narrow, triangular slips)* escape, with the same exceedingly restless volubility; the marginal bristles not yet being stiffly extended in a plane, but ruffled up and down like the bristles on the undulating borders of a thistle-leaf. As they feed and the tissues become scatent, the entire form of an Oxytricha is presently acquired.

I have observed still another development of Oxytricha; its first source, however, being as yet unknown to me. There appear on the field of action numbers of quaint-looking, big-eyed balls, about $\frac{1}{100}$ line thick, snouted, as it were, with a sort of "hair-lip" resembling a duck's bill; the stiff bristles within the bill-shaped mouth quivering with a sort of expressive smirk, and looking altogether odd.

They come full-sized and booming upon the stage, and in this respect argue a direct derivation from certain haw-shaped, five-costate vorticellan buds, with a contracted *pappus* of stiffened cilia around the orifice, spinning and rebounding like humming-tops. The "goggle" now soon becomes stationary, and shortly after, rapidly expanding, and its germinal speck or nucleus (the "eye") particularly enlarging, within half an hour it dropsically flattens out into a pretty well-sized Oxytricha,* by a similar sort of internal fluxile commotion of particles as when the animals dissolve into molecular "sauce."

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* The figures L and M, p. 447, in Carp. "Micr." seem to belong here.

But Oxytricha is not a perfect animal. It has no membranes, and evidently no fibrous tissues at all. The entire texture apparently remains in an embryonic, *vitelline* condition, as yet.

I have in a single instance witnessed what appeared to be the *moulting* of a perfect Oxytricha. The front border was somewhat removed from the body, which it crowned like the crest of an ancient helmet, and within each rigid bristle ("style") *as within the fingers of a glove*, was contained the far more delicate corresponding one of a clear (and now entirely yolk-less-bodied) animal,—the lower quarter being in a like manner hidden in a part of the old coat. I thought it was plainly identical with the following animal, whose development brings us up to "*Paramecium Aurelia.*" As I have not been able to chance upon such a moulting process again, I reserve the decision.

A clear (internal) animal is apparently developed by this moulting of the Oxytricha. Of the latter, the very bristles, when detached, seem to possess individual vitality, singly beating about for quite a while, and even empty coats (apparently *shed*) sometimes behave as if they had a life of their own. At all events, at a certain epoch there appears at once the next form in question,† in full size, upon the field; the transparently clear bodies sometimes showing a scalloped border, and alveoli, as of *former* yolks, *extruded*—that soon smooth over. In outline, the animal appears somewhat like the soft parts of an oyster, being flat, somewhat lop-sided, in the shape of a human ear—tip foremost. It is "doubled up" at the straight border, the broader lower rim being overlapped, *as by a lid*, with a smaller, but thicker, upper flap ("lorica") containing one clear germinal speck. This animal *opens like a book*, undoubling its flaps; and it is thus that it devours its prey (such as conferval spawns, etc.), by bodily enveloping them like a ray-fish (*Raya*) enfolding the nourishment as if *fused around it*, and the whole surface exhibiting an incredibly rapid ciliary commotion *during the whole process of digestion.* This done the cloak again unfolds, often appearing like two stipules, e. g. of a *Liriodendron*, and then closes up again. On drying up, or in search for air and *moisture*, the animals are often seen to mutually enfold each other's flaps. This cannot, however, be interpreted as a sexual copulation, seeing that in the first place they neither develop any eggs; nor, in the second place, do they even extrude yolks; but their onward development is *by encystment*.

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* This somewhat resembles fig. F, turning, by fluid expansion, into fig. E, (Carp. Micr., *ibid*). Fig. F, however, requiring to be duck-billed, as it were, and fig. E to be lop-sided and the nucleus more central.

† Perhaps the "*Euplotes*" of authors. Their descriptions and figures, however, offer nothing that sufficiently resembles this very common form, so as to be readily identifiable.

Within a few minutes such a full-grown "oyster-grub" is seen contracting its big flap, so as to present the shape of a hat with a warped rim and hemispherical crown, the latter formed by the blunter lobe, which contains the "speck" or "eye," and, contracting, gets hemispherically rounded. Very soon (with a constant adjustive quivering of the cilia-like bristles) the whole is rounded into a globe, wherein the doubled inside forms a ciliate hiatus. The latter, soon contracting, closes over. Nothing is now seen but a ball with a clear "germinal speck." In a few hours a *double* contour (the outer one granular is exuded. The speck or "eye" itself now becomes dusky and granular. It increases. It bisects "Gregarina-" fashion. Each pear-shaped segment again acquires a clear speck or "eye." They elongate, being connected by the blunt ends,—each one tapering to a very soft apex; and these very large germs or pseudo-Gregarinas at last become liberated, probably as "*Paramecium Aurelia*," which now appears *full-grown* on the scene.*

It is about the length of the Oxytricha, about three times the length of the revolving wool-fringed grubs of the Oxytricha, and by all means more complexly organized than either. It has the shape of the (shoemaker's) *last* for a very elegant ladies' shoe. From one side it therefore gives the figure as of a foot-print (without the toes); but viewed on edge has a pointed rear end, and in this profile it "takes the name" of Paramecium *caudatum!* The ankle of that "last," however, is beveled away leaving the instep a ridge. Its oral aperture, not clearly distinguishable, is in the middle, slanting almost longitudinally for about one quarter of the length of the body. It seems to work its way, dashing by vacuole-contraction, while at the same time revolving by a roundabout coat or film of short pubescence, almost too delicate to be made distinct. In what appears to be the abdomen it has the well-known circular *pulsatory vesicle*, wherewith it propels itself, and around which point it is often seen spinning like a wheel. A system of fusiform or bulbous vessels radiating around the pulsatory vesicle, contract, as the vesicle expands, and *vice versâ*, as is well-known; and some seem to have several such *pulsatory* "vacuoles." The body is turgid with rather small germinal yolks. These animals I have never seen bisecting either lengthwise† or across, nor copulating sexually. The latter, however, seems to take place with the Planariæ, which also show the staghorn-shaped entrails analogous to those of the marine (true) Planariæ and joints of the tape-worm, whose detached individuals are also known to hover freely in a liquid, like these Ciliata. It is supposable that the large Paramecium, with pulsatory organs, is the young Planaria; but it is certainly not itself an adult body.*

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* The developmental experiments were made in small parcels, forming a drop (between glass-slips, somewhat held apart) and preserved from exsiccation.

† Ehrenberg's figures, however, show it in that process (if not a mistake).

The further and most remarkable of all these progressive and retrograde developments is the following. The well fed and full grown but *entrailless* Paramecium Aurelia becomes slow and lazy, grayish with the teeming germinal contents, and in a few hours may be seen motionless as the fabulous "Kraken" of ancient Norway. Its *entire substance* now commences swelling forth into compact, fragiform "germinal clouds;" while a great many of the germinal specks, now become less obscured, are plainly discernible as of the clear, "*currant-shape yolks*" kind. These in a short time however, commence *moving;* and while some of the smaller ones are being propelled by adherent motile granules (probably the "Acineta" *Auct.*), the larger ones move by contraction, viz: their "circlet" becoming *everted,* they now *crawl forth,* like a very limpid *grub*—resembling a sort of *tumbling sac!* This "tumbling" is produced by the most marvellous facility it possesses of protruding long, blunt branches, (like little stove-pipes) on *any* part of its surface, by eversion; so that in a few moments its form is entirely changed. Its contents are a visibly and rapidly circulating *so-called* "rotating protoplasm," composed of mostly very transparent *individual vibrionic particles,* partly bulky, but mostly very small. Some dark (red or brownish) vibrionic dots are also discernible.

It now takes the form which has been called "Amœba." This form, however, likewise occurs, when similar yolks or "acinetæ," are expelled from *vorticellan* bodies. In either case the "tumbling-sac" lastly attains a versatile-campanulate star-shape *with* "*pseudopodia,*" from which break forth volumes of minimal vibrios, and quite large, cylindric bits of rods, or (*pseudo*)-"bacteria." The latter here are thicker than fungine bacteria, and are neither coated nor ellipsoidally shuttle-shaped, but bluntly cylindric, like cartridges or butting rams. They possess a very forcible automatous motion, and like to congregate, and with great violence keep butting all together, one against the other, in a heap; and within a few minutes, the whole appearance has dissolved and passed into a "germinal cloud" of molecular "vibrionic" cell-life.

Besides the above circuits of generations, which probably comprise both the pulsatory Paramecians proper (Aurelia) and the Vorticello Oxy-trichans (through the mediation of the "oyster" or "porte-monnaie-grub"), there occur frequently some *analogous* forms, such as "Kerona" and "Trachelium."

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* Pritchard, etc., figure the planaria-like form as "adult Paramecium."

The last form of all to appear in infusions, etc., seems to be the well-known *Rotifer*, the developments whereof are perhaps related to some of those above detailed. It is, however, most probable, according to the observations of Prof. L. Agassiz ("Ann. Nat. Hist." vol. ii, 1850, p. 157), who saw forms resembling the undulate-fleeced ("Paramecium Kolpoda") grubs *bred from the eggs of* "*Planariæ*,"* that such are the adult forms (*if* adult). I have only occasionally met these swelled and pear-shaped, dusky bodies, traveling both back and forward with equal facility, and remarkable for the stag horn-like designs of their *entrails;* thereby evincing something like a membrane in their organization, but the organ being itself of a sort of glandular structure. They are also said to bisect, like the Oxytricha. Some *young* ostensibly planarian forms, larger than Paramecium Aurelia, blackish, and shaped like a short, broad lancet blade, which I have seen "bisecting," did so only while *encysted*, rotating in the manner of mill stones; and the escaping animals had as yet no trace of the visceral organization, as found in the adult Planariæ (and also observably developed in Rotifer).

We are therefore still in doubt as to the true, ultimate genus and species, and therefore have to *suspend* classification; the points of interest, here submitted, being the important physiological processes and transformations on the one hand, and the fallacy of foregone diagnostic terminology on the other. The description of the genetic phenomena of the so-called Fresh Water Algæ, in their *unbroken continuity of developments*, as experimentally ascertained, I reserve for a future paper.

ART. XIII.—*Tornadoes of the Southern States;* by HAMPTON S. WHITFIELD, Professor of Mathematics in the University of Alabama.

THE tornado is a storm which has two distinct movements, the one progressive along the surface of the earth, the other gyratory, like that of a top spinning on its axis. It whirls as it goes and its force is so great that no structure of wood, brick or stone can stand before it. Even the solid hills quake and the ground trembles beneath its march. Fortunately, its track in this country is very narrow. I have not yet found traces of any one exceeding two hundred yards in breadth.

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* This is no doubt what authors figure and describe as the "*adult* Paramecium Aurelia." with its stag-horn shaped intestines and swelled bodies. I am also under the impression that it was *this* form which I had formerly frequently observed in what appeared to be spontaneous *coitus*.

The gyration of the tornado is not horizontal but spirally upward, for it not only displaces heavy bodies, but carries them up to a considerable elevation. I have seen a pine tree, sixteen inches in diameter and sixty feet long, float out from the black vortex of one, at the height of a quarter of a mile, and sail round, to all appearance, as light as a feather.

In May, 1868, a very destructive tornado originated in the extensive flats on the Bigbee river, south of Columbus, Miss., and crossed Pickens and Tuscaloosa counties, Ala. A few days after its passage I visited the wreck of a large, two-story, framed house which had stood in its way, twelve miles east of Columbus. The timbers were scattered for miles along its path, and all the family, five in number, were killed. Their bodies were found at some distance from the site of the house, one nearly a quarter of a mile away on the next hill. The clothing of the females was stripped from their bodies. The front portico of the house rested on a single piece of pine sixteen inches square and fifty feet long. There were no timbers framed into it and it was, therefore, moved by the force acting only on its own surface. It was carried across the intervening valley to the adjacent hill, into which it plunged end foremost, opening a deep trench. Here it shivered, and leaving a short fragment, passed on. Lying on the ground, under the portico, was a solid iron shaft, an inch and a half in diameter and weighing sixty pounds. It was transported more than a hundred yards.

To produce such results required a pressure of at least one pound to every square inch, a force fearful to contemplate as possible for the wind. Some idea can be formed of it when we reflect that this house, being fifty feet long by twenty-five in height, presented a front area of one hundred and eighty thousand square inches, and therefore encountered a pressure of ninety tons. The velocity of the wind, necessary for such an effect, must have been one hundred and sixty miles per hour. Let it be taken for granted that this velocity was at the point of greatest energy in the gyration, for it must have a point of greatest and one of least effect. The point of greatest energy or effect on stationary objects is on that side where the direction of gyration coincides with that of progression. Should the advancing speed of the storm just equal the velocity of rotation, then on one side the effect would correspond with the sum of these velocities, while on the other it would be entirely neutralized; for, on this side, the wind would move backward as fast as the tornado would go forward.

It is impossible to determine accurately the average speed of our tornadoes, but careful observation and comparison have led me to fix upon forty miles per hour as very near the truth.

This must have been about the rate of one whose formation and progress for several miles I witnessed, but the spectacle was so absorbing that I entirely forgot to time it by the watch. On another occasion, in the night, I listened, in company with several others, to the roar of one passing at the distance of two miles, and we all agreed upon forty miles as about its rate.

In May, 1840, a part of Natchez was destroyed by a tornado, the most dreadful that has ever passed through the Gulf States. It crossed the river at two o'clock, P. M., and at 9 o'clock burst upon west Alabama in the shape of a rain storm, pouring unprecedented torrents. Its rate was, therefore, about forty miles. The Pickens county tornado, if the accuracy of two witnesses, fifty miles apart, can be relied on, exceeded this rate a little. For the sake of analysis let forty miles be taken.

The progress of tornadoes is always, in the Southern States, from a point south of west to a point north of east, and, although sometimes varied by prevailing winds, this direction is characteristic and due, as I shall show, to the rotation of the earth on its axis. The gyration is always from right to left, and this, also, as is known, is an effect of the earth's rotation.

On the south side of the tornado, then, the greatest power is exhibited, for here the gyration is forward or coincident with the translation, while on the north side the gyratory motion being contrary to the progression, the effect is least. At the front and rear, where the gyration crosses the path, the effect must be the same.

Suppose, then, that the velocity of gyration is one hundred and twenty miles per hour. Add forty, the speed of progression, to the south side, and the velocity of impact, against stationary objects, would be one hundred and sixty miles per hour. Subtract forty on the north side and it would be eighty. Now, wind moving eighty miles an hour will not necessarily throw down trees and wreck buildings, but at a speed of one hundred and twenty or one hundred and sixty miles, it will level all obstructions. The most destructive energy, then, is developed in the south semi-circumference of the whirl, and the diameter of the gyration must be, in most cases, much greater than the apparent path. The aspect of the wreck along the path of these storms is in conformity with the above analysis of forces. Where they traverse forests, by far the greater number of trees are thrown eastward, and nearly parallel to the line of progression some fall northward and some southward but none lie backward parallel to the track. The framed house in Pickens county stood in the southern rim of gyration and all its fragments, together with its inmates, were carried eastward.

One of the most remarkable accompaniments of the tornado is the black column or spout, extending from the cloud down to the surface. It precisely resembles a column of black smoke, such as pours from the pipes of a steamer burning pine wood; it is in fact condensed vapor or cloud, intensified in blackness by the dust and rubbish carried up from the ground. The tornado is a shell or hollow cylinder of air, and all its energy lies in its rotating rim which is powerfully compressed by two antagonistic forces, centrifugal and centripetal. The rapid whirl draws the air from the center toward the circumference where it is met and opposed by the in-rushing winds. There is, consequently, a rarefaction, a great reduction of temperature by expansion, and condensation of vapor within the shell.

The spout does not hug the earth continuously, but rebounds or *ricochets* along the uneven surface, often skipping the valleys but generally desolating the hills. It is disposed, however, at every recurrence to strike at the same points. It is not an established fact, but it is commonly believed, and with some reason, that the tornado does, in the course of years, return along its beaten path, and that it is unsafe to build where one has ever passed. The house in Pickens county stood on a hill from which a log cabin had been blown away some thirty years before. I witnessed the last of three, which have passed along the same track. Near Hernando, Miss., three have followed an unvarying line. It is probable that there are some localities more favorable than others to the generation of these storms, and if this is true, then the law of direction, hereafter explained, accounts for their progress along the indicated path.

Such an opportunity, as fell to my lot, of witnessing the formation and course of a tornado is rarely enjoyed, and the phenomena observed on that occasion are of great value in illustrating the origin of these whirlwinds. On the 29th of April, 1867, at 10 o'clock A. M., I was approaching Tuscaloosa, on the Elyton road, the general direction being east and west. The weather was hot and oppressive, while a perfect calm prevailed both at the surface and in the upper regions, for the leaves were not stirred upon the trees and the heavens were covered with fragmentary clouds, perfectly at rest. Occasional large drops of rain fell, and there was, now and then, lightning. The atmosphere was evidently surcharged with vapor and in a condition of great electrical excitement. At the distance of three and a half miles from town, an elevated ridge, over which the road passed, afforded an extended view, and I saw a mass of black cloud, detached and hanging over the western horizon. It appeared nearly circular in shape with the exception of a slight angular projection, like an inverted cone, at its lower edge. I afterwards ascertained that it was at this time about five miles distant from me, and a calculation, based upon the estimated angles, fixed the elevation of its base above the surface at about fifteen hundred yards, and its diameter, considering it a sphere, at about six hundred. It was entirely at rest.

The first view of this cloud suggested to me the possibility of a tornado, and I watched it closely as I drove along in my buggy. While I was driving, leisurely, more than a quarter of a mile, it maintained its position and outline unchanged. At length a farm house with its shade trees intercepted the view for about a minute, and when I came again in sight of it, the projection beneath the cloud appeared in violent commotion. There was now no longer any doubt of the character of the phenomenon about to be exhibited, and satisfied, from a knowledge of the general direction of tornadoes, that it must come near me, I leaped from the buggy and released the horse as quickly as possible, in order to give him a chance for his life. This did not occupy more than a half a minute, and when I turned to look again, the black column was formed, reaching from the cloud to the ground. A few moments showed that it was rapidly approaching. I remember noticing small fragments of cloud moving toward it from the north, but there was no perceptible breeze where I stood. When about a mile distant I saw that it would go south of me, and at this time I first observed the surface drift, which appeared like an innumerable flock of birds, flying around the summit of the column, and here, too, the pine tree spoken of emerged from the vortex, and settled slowly to the earth. The column was now much shorter than when first formed; the cloud had descended much nearer the surface. It passed about three hundred yards south of my position and at this point the first electric discharge took place. The lightning zigzagged down the column, shedding through it a lurid glare. The roar was deep-toned and powerful. The gyratory motion was distinctly visible. When a little further on, it became so enveloped in clouds as to be no longer distinguishable, but I knew, by the now frequent peals of thunder, that it was increasing in violence and levelling all things in its path.

This tornado was formed about a mile and a half southwest of Tuscaloosa, over an extensive marshy flat, where an observer characterized it as a "big whirlwind." It was not destructive at first but grew in energy as it progressed, and two miles from its starting point, threw down a dilapidated building. About six miles from Tuscaloosa it struck a log cabin in which were sitting a woman and several children. Every log above the floor was carried away, while the occupants were left uninjured. Twelve miles further on it performed a similar feat, taking off every log of a house without the slightest hurt to any of the family, all of them having taken refuge within on its approach. This is remarkable, but there are other like instances well authenticated, and it is commonly believed that a log house is the safest retreat. The direction of this tornado was east by 20 degrees north. After its passage the air was cool and pleasant, and, at 4 o'clock in the afternoon, heavy rain came from the north, followed, for the next few days, by clear weather with northwest winds.

The most remarkable fact, disclosed by the phenomena of this storm, is the inherent power of progression which it unquestionably possessed. After the gyration was established it began at once to travel eastward, not driven by any wind, but ploughing its own way through the tranquil atmosphere with tremendous speed. Here is presented a problem, which, so far as I know, has not heretofore been propounded. Its solution is important to the science of meteorology. The fact that tornadoes invariably move from the southwest to the northeast is well established, as also the fact that, by an impulse acquired from the earth's rotation on its axis, they gyrate from north by west to south. This backward gyration is thus explained: All parallels of latitude decrease in diameter, and therefore in circumference, as we go toward the poles of the earth. As they all revolve in twenty-four hours, it follows that every one, approaching the pole on either side of the equator, moves around more slowly than the one preceding it. Therefore, a current moving southward, to the vortex of a tornado in the northern hemisphere, finds that vortex rotating eastward with a superior velocity, and is left behind, or, projected to the west, while, for the same reason, a current blowing northward to the vortex, finds it rotating with inferior velocity, and, preserving its own easterly momentum, is hurled forward or projected to the east. Thus the south half of the rim being impelled eastward, and the north half westward, the backward or left-handed gyration is fixed and maintained. Just the reverse is true in the southern hemisphere of the earth, while on the equator the gyration would be free to take either direction.

Espy denied the whirl of tornadoes, while Redfield, another eminent writer on the subject, maintained it. The question has, I believe, long been settled in favor of the latter.

I now propose to show, also, that the translation of tornadoes from west to east is effected by the earth's rotation on its axis. But, as this proposition is in conflict with the theory of cause and formation, as enunciated by Espy, and supported by the higher authority of Loomis, it will be better to state briefly that theory.

"Storms," says Loomis, including tornadoes, "are caused by a strong and extensive upward motion of the air, by which means its vapor is condensed by the cold of elevation." To epitomize his language, the rays of the sun heat the surface of the earth without heating, except slightly, the atmosphere through which they pass. The surface warms the air near it, while, at the same time, radiation more easily takes place from the superior strata, thus reducing the temperature of the upper regions. Since air expands and grows lighter with increase of temperature, and contracts and becomes heavier from diminished heat, it follows that, under this influence, "the atmosphere is in a state of unstable equilibrium, *and the lower strata tend continually to rise and take the place of the upper.*" The ascending air, coming under diminished pressure, expands, and therefore cools. At a variable height, depending on the dew point, or the quantity of vapor, the cooling causes condensation or cloud. Condensation of vapor sets free latent heat. This liberated heat warms the surrounding air and causes it to ascend higher. Another expansion takes place, followed by another cooling, another condensation, and another liberation of latent heat, and so on indefinitely, or until all the vapor held in suspension is disposed of. Thus dense clouds of great depth are formed, and rain, hail or snow, two, or all, result. The ascending column is continually fed by surface currents converging to the center, and the violence of the storm is in proportion, as Espy says, to the "steam power" of the air; that is, the amount of vapor suspended in it.

Olmsted, in a lecture on Espy's theory, has, I think, shown that this process of alternate cooling and heating is impossible. The truth is, that the liberation of latent heat simply serves to retard the too rapid condensation, and without this check the violence of storms thus produced would be tenfold greater.

There can be no question that rain is caused in this way. The piled-up clouds, called *cumuli*, so common in summer, are produced by ascending currents, and from them result ordinary summer showers, but there is a vast difference between the summer shower and the tornado; so great, in fact, that we are compelled to attribute them to entirely different modes of generation.

In quoting Loomis, I have italicized one sentence. Owing to the "unstable equilibrium," caused by surface heat and radiation above, he says: "*The lower strata tend continually to rise and take the place of the upper.*" Here he has stated the effect for the cause. The fact is, that *the upper strata tend continually to descend and take the place of the lower.*

Espy, endeavoring to establish a favorite theory, makes the quite untenable assertion "that the air of the upper regions is specifically hotter than the air at the surface;" which means, if it means anything, that a pound of air in the upper regions contains absolutely more heat at a given temperature, than a pound at the surface. All this belongs to a philosophy which has been long since exploded; and in fact, every sound philosopher must at once perceive that, under such conditions, no currents could either ascend or descend; the "specifically" hotter, and therefore lighter air, at the top, could not possibly come down, because it would become *sensibly* hotter, and therefore lighter than the air below; and the "specifically" colder air at the surface could never rise, for a corresponding reason. An "unstable equilibrium" could not exist. My prescribed limits forbid a more elaborate discussion of this point.

If an "unstable equilibrium" exist, the upper strata will tend to sink, and *a descending current must necessarily produce an ascending current.* Again, the "unstable equilibrium" requires that the air from the upper regions, when it reaches the surface, should, notwithstanding its compression, be colder than the surface air, or else it could not undermine and force it up.

This descending current may be a contracted column, pouring down rapidly, or it may be the entire body of the atmosphere settling slowly over a wide area. The latter process goes on where there is any local cause of heat, as in the case of fires, and the expanded column is pushed up by the surrounding air pressing upon its base. The former takes place, under favorable circumstances, when a great expanse of air is heated up uniformly at the surface. Here the descending stream is a rapid spouting column, and the ascending one a slow compulsory uprising of the whole body of surrounding air. In this case, if the temperature of the falling air is below the dew point of the lower strata, condensation takes place and cloud is formed. If the difference is very great the down-moving current will be very powerful, and the centrifugal force resulting from its gyration will generate an immense vacuum or vortex, into which the air from beneath will rush violently, forming a secondary vortex, which is the spout of the tornado. Should the ascending current fail to concentrate into a spout, the storm is known simply as a hail-storm. These differently named movements have a similar origin, and present similar phenomena. Nearly every tornado exhibits hail, and nearly every hail-storm, at times, a spout. At a considerable elevation the descending column, before it is compressed to any great extent, is icy cold, and, by expansion in the vortex, its temperature is reduced ten fold, so that the vapor of the air rushing in from below is instantaneously frozen.

The tornado is, then, a tremendous maelstrom in the atmosphere. Its vortex, extending possibly to the utmost limits of the air, and widening out at the top, involves a vast extent of the upper strata in its commotion, often giving raise to rain storms and secondary tornadoes many leagues distant from its path. Its prodigious force is due to the concentrated momentum of all the currents moving to the common center; is the sum of the forces of all the centripetal streams set free in a contracted area.

It is a well-established fact that tornadoes are translated from west to east. It is also admitted that they are generated in a calm atmosphere. It is, therefore, surprising that Espy and other advocates of the "ascending column" theory, did not perceive that their storms must, unavoidably, be translated in the opposite direction, or from east to west. As the earth rotates to the east, carrying the atmosphere along, it follows that the greater the elevation or distance from the axis, the greater must be the velocity eastward. Hence, an ascending column, penetrating the upper and more rapid strata, is left behind or projected to the west. Overlooking this principle, however, they assign as the cause of the direction of tornadoes an elevated and constant eastward wind, maintaining that it seizes the top of the tornado and drags it as a ship drags its anchor. But there is no cohesion in æriform columns, as in cables, and it is, therefore, impossible for a force applied at the summit to pull the base along. Espy contradicts his own theory frequently by asserting that the tops of rising columns, forming cumuli, are "shaved off" by upper currents. It is very evident that if a strong wind from the southwest should be blowing at a great elevation while a tornado, formed according to Espy's theory, is raging in an underlying calm, the earth's rotation would carry the storm westward, notwithstanding the contrary wind above, for this would simply "shave the top" and bear it off, while the storm went on the opposite course.

There is but one way in which an elevated current can affect the direction of a tornado, and that is *by descending into its vortex.* In this mannner only can it communicate its own momentum and control the path, and in this manner it often does produce a great variation from the normal line. Neighboring winds, bordering the calm in which the storm originates, may also, in a way easily explained, cause a deflection.

It has been shown that a column of air ascending in a calm must be deflected to the west by the earth's rotation. For the same reason one descending must be impelled eastward. Tornadoes always travel from west to east in obedience to this law.

The process of formation is now easily comprehended. In an atmosphere supersaturated and unduly heated at the surface, let a calm prevail over many miles of territory. The equilibrium is powerfully disturbed. A great volume of elevated air begins to settle down, forcing up the lower strata. In descending it meets and mingles with the warm, moist air beneath, forming cloud. Whatever latent heat may be evolved by condensation is at once reabsorbed by accessions of cold air from above. The descending stream, fed by oblique tributaries from all points of the compass, begins to gyrate. From centrifugal force result rarefaction, cooling, and further condensation. The center of the vortex is a partial vacuum, and from below a column is drawn up into it. This ascending column also takes on gyration, and the tornado spout is created. But this spout, the effect of which is so terrific, is nevertheless secondary and incomparable to the tremendous commotion of the great whirl above. The two columns meeting, vast volumes of air are thrown off by centrifugal force in all directions, and the cloud expands and enlarges with amazing rapidity. This expansion is often mistaken for the progression of the storm; the cloud appearing to approach one observer from the northwest, perhaps, while another sees it rolling up from the south. In the meantime the descending stream has pressed the cloud down upon the surface, where it envelopes everything along its path in almost total darkness. At length the superior vortex becomes so great in diameter that the spout is disrupted or so diffused as no longer to exhibit the concentrated power of the tornado. The whirl becomes co-extensive with the overhanging cloud, and the meteor is now a rain or hail storm of tremendous violence. The tornado of April, 1867, near Tuscaloosa, raged as such for about thirty miles, when it lost its distinctive feature, the spout, and poured such torrents as to cause a great freshet in the Warrior river. It has already been stated that the Natchez tornado expended itself in a tremendous rainfall, and this is the termination of all these storms. They are of variable duration and extent, continuing until the equilibrium of the atmosphere is restored.

Loomis has explained, but not to entire satisfaction, the cause of the northward inclination of tornadoes. He rightly ascribes it, however, to the decreasing diameters of the successive parallels of latitude. If a tornado should form on a parallel of 45 degrees, its vertical axis would make an angle of 45 degrees with the earth's axis of rotation. It follows, then, as would readily appear from a diagram, that the currents descending obliquely to the vortex on the south side, would approach the earth in a direction more nearly perpendicular to its axis than would those descending on the north side, for the latter would be more nearly parallel to the earth's axis. Then, by reason of the earth's rotation, the eastward impulse of these southern currents would be greater than the westward impulse of the northern currents. The deflection of the former would be greater than that of the latter, and, consequently, velocities corresponding, there would result a greater centrifugal tendency on the northeast than on the southwest of the vortex; and the effect increases with the latitude.

This will plainly appear from a diagram. Let a circle be described representing the rim of a tornado. Then let two lines be drawn, one representing the resultant of the forces of the southern currents, and the other the resultant of the forces of the northern currents, each deflected as it approaches the vortex, but the former more than the latter. Each will maintain its influence, from its point of contact, around to the point where the other impinges, and that from the south, having the greater impulse, and, acting on the northeast semi-circumference of the rim, will press the storm northward.

The process of hail-formation takes place in the great vortex above the base of the cloud, probably at considerable elevation. There the gyration, not impeded as it is at the surface, presents a vast and rapid whirl, the centrifugal force of which causes extreme rarefaction, accompanied with intense cold at the center. The saturated air carried up into it from below, by the spout, furnishes the material for hail. Congelation follows instantly upon condensation, and the stones, tossed about in every direction, are finally thrown out upon the circumference, where they are free to fall.

Electricity, which has been supposed to play an important part in the generation of tornadoes and hail storms, is but an effect. It is excited and set free by the condensation of vapor, and is developed in proportion to the amount and rapidity of cloud-formation. In the Tuscaloosa tornado the gyration had formed and travelled three-and-a-half miles when the first flash occurred.

The tornado may be looked for in the winter and spring months, during the prevalence of southern winds. As stated above, a descending column requires, as a prerequisite, a surface stratum uniformly heated over a wide extent. As the sun advances north, after the winter solstice, the south winds that reach us blow from low latitudes on the Gulf. They have then, not only abundant moisture, but a temperature higher than is due, at any time before June, to the effect of the solar rays in our own latitude, and therefore answer the necessary condition of a stratum heated uniformly over a large area. Our tornadoes consequently do not grow out of the heat rays that penetrate our latitude, but rather from the heat of the tropics, transported hither in the winds; and this is the reason of their appearance either in the daytime or night. We never witness them in the hot summer, because then the lower atmosphere is warmed by direct rays, and a uniform temperature, over a wide extent, is impossible, from the fact that the cleared lands and forests, hills and valleys, are heated unequally, giving rise to ascending columns and moderate storms. If the theory of Espy were true, then July, August, and September would be the tornado season with us, for in these months moist south winds blow, and the sun's rays are most powerful.

The cause of the greater violence of storms produced by descending air is not difficult to comprehend. When a downward column becomes well defined, it is fed, as before suggested, by tributaries flowing obliquely down from all sides. The very top of the atmosphere sinks freely into the stream. The case is precisely that of a heavy body descending an inclined plane; but the heavy body is here a great ocean of air superimposed upon another abnormally elevated in temperature, and therefore abnormally rarefied. The tornado is a process by which the one seeks to settle beneath the other, and is not unlike what would occur should an opening be made through the bottom of some great reservoir of water.

On the other hand, when the transposition begins in consequence of the movement of a definite column, ascending from below, the earth's surface presents a limit, and the tributaries cannot, as in the other case, flow obliquely in straight lines without leaving a vacuum beneath, and that is impossible. They must, therefore, though ever seeking to mount upward, still trail along the surface until they converge at the center. An impediment of this nature would find adjustment in many uprising columns of limited power, capped with cumuli and resulting in showers, but no one vast, absorbing vortex, could monopolize the whole movement, and shake the firmament with its might.

The effects of the tornado are often, to all appearance, very anomalous and extraordinary. It strips the feathers entirely from fowls when the gust strikes them from behind. In a row of buildings in a line with its direction, it may throw down the middle one, and leave the others standing. This is possible when they are located on the central line of progression, for then the blow is delivered by the front and rear of the rim, gyrating at a right angle with the row, and every house must stand or fall, according to its own power of resistance. Or, if a firmly-built house withstand the outward shock, it may yield to the elastic force of its inclosed air, expanding, as it must, with a sudden and powerful effect, that instant the vortex, which is a partial vacuum, passes over it.

Again, pointed pieces of wood or iron pierce or penetrate wherever they strike end-foremost, and pebbles are imbedded in soft wood by the force of the blast. This is not so remarkable when we reflect that the velocity of gyration is three hundred feet a second—and it may go far beyond that—which is greater than the speed of an arrow shot from a bow. On the track of the Pickens county tornado a rafter of a house was found driven through a pine tree.

The whirling sand storms of the desert are probably tornadoes without the accompaniment of clouds with thunder and lightning. The great desert of Africa presents an uninterrupted surface of sand to the sun's rays. The lower strata over its broad expanse are heated uniformly, and this first requisite is answered. But the dryness of the air fixes the dew point at an extremely low degree, and there can consequently be no condensation or cloud. Yet the vortices may form as in other localities, and vast quantities of sand take the place of cloud.

My information is too limited, however, to justify any positive theory in regard to these desert storms. I merely conjecture that they are formed like the tornadoes of our States, but that, unlike them, they are generated from direct heat rays absorbed by the surfaces immediately under them, and therefore appear generally in the daytime, and in the summer months, as well as at any other period.

ART. XIV.—*Preliminary Notice of New North American Phyllopoda;* by A. S. PACKARD, Jr., M.D.

THE following brief descriptions are extracted from a monographical notice of our Phyllopod Crustacea, which, with the exception of the Branchipodidæ, so thoroughly investigated by Prof. Verrill, have been sadly neglected. It will be noticed that North America is rich in the species of Apus, more so than any other quarter of the globe so far as yet known. It is a little singular that no species has yet occurred east of the Mississippi river. The species of Limnadiadæ are probably more abundant than naturalists are aware of, and the attention of collectors of shells is called to these Cyclas-like shelled Crustacea, whose shells may not infrequently be mistaken and passed by as simply species of Cyclas. For the privilege of studying the species of Apus I am indebted to Dr. William Stimpson, who has loaned me the specimens placed on deposit in the Chicago Academy of Sciences by the Smithsonian Institution, and to Prof. A. E. Verrill, who has contributed the specimens in the Yale Museum; while the Museum of Comparative Zoology at Cambridge has contributed a new Apus from northern India, and for the Limnadiads my acknowledgments are due to Mr. G. W. Belfrage, an industrious collector, and Prof. E. S. Morse, who have given several species to the Peabody Academy of Science.

APODIDÆ.

The known species of Apus may be for convenience divided into three sections, characterized in part by the length of the shield, or carapace, the highest forms having the shortest carapace, those with the longest shields, as the European *Apus cancriformis*, approximating in this and other characters to the genus Lepidurus.

Section *a* comprises *Apus longicaudatus*, *Lucasanus*, *Newberryi*, and probably *Domingensis*.

Section *b* comprises *Apus æqualis*, and *Guildingii*.

Section *c* comprises *A. cancriformis* and *Himalayanus*.

Apus longicaudatus Leconte, Ann. N. Y. Lyceum.

Prof. Dana's type specimen, which is now very imperfect, was labelled "Rocky Mountains, near Long's Peak." Four specimens from "Texas, J. H. Clark, No. 3." Three specimens from "pools near Yellowstone river. Dr. Hayden, No. 6." Mus. Chicago Acad. Both sexes occurred, the females having eggs. James's *A. obtusatus* (Long's Expedition) is probably this species. *A. Numidicus* Lucas, from Algeria, in the form of the carapace seems to be allied to *A. longicaudatus*.

Apus Lucasanus, n. sp.—♂ closely allied to *A. longicaudatus*. The frontal doublure rather longer than in *longicaudatus*, and hypostoma a little smaller. Maxillipeds shorter and smaller, and telson longer than in the preceding species, with three median spines above. Anal stylets less spiny.

No. of segments behind posterior edge of shield 33; no. behind the last pair of gills (including telson) 13; length of body (excluding caudal stylets) ·94; of carapace along the middle ·37; total length of carapace ·48; length of tergal carina ·24; distance from anterior end of carina to front edge of carapace ·16; length of caudal stylets ·57; being a little over half the length of body; breadth of shield ·40 inch.

Six specimens in a bottle labelled "Kansas, No. 5," and containing thirteen ♀ *A. aequalis*. Mus. Chicago Acad. They cannot be distinguished from St. Lucas specimens.

♀, carapace longer than in ♂, and caudal stylets not so heavily spined. No. of segments behind posterior edge of shield 29; no. behind last pair of feet 11; length of body ·80; of carapace along the middle ·30; total length of carapace, ·40; length of tergal carina ·25; distance from front end of carina to front edge of carapace ·16 (stylet broken); diameter of egg-sacs ·09 inch.

One specimen from "Cape St. Lucas, John Xanthus, No. 4." Mus. Chicago Acad.

Apus Newberryi, n. sp. ♀.—This fine species differs chiefly from *A. longicaudatus* in the shorter maxillipeds, and much longer, smooth telson with 3 instead of 4 median spines, and in the smooth, finely spinulated caudal stylets, while the carapace is longer. No. of segments behind posterior edge of carapace 29; no. beyond last pair of feet 11; length of body 1·78; of carapace along the middle ·75; total length, 1·00; length of tergal carina, ·50; distance from front end to front edge of carapace ·30; length of caudal stylets, 1·05 inch.

Two specimens from "Utah, J. S. Newberry, No. 1." Mus. Chicago Acad.

A. æqualis, n. sp. ♂.—In this species the carapace is much longer than in the preceding species, the eyes are larger, the tubercle behind them is smaller, and the gills reach much nearer the telson.

No. of segments behind posterior edge of shield 23; no. behind last pair of feet 11; length of body 1·15; of carapace along the middle ·56; breadth ·56; length of tergal carina ·35; distance from front end of carina to front edge of carapace ·21; length of caudal stylets ·75 inch.

Two specimens from "Matamoras, Mexico, General Couch." Mus. Chicago Acad.

♀. The telson has 5 median spines and is shorter, and the stylets have more numerous and shorter spines than in *A. Newberryi.* The under side of the telson is much smoother than in *A. longicaudatus*, and the outer gill of the 1st maxillipeds is a little longer and more acute. No. of segments beyond the hind edge of carapace 25; no. beyond the last pair of feet 9; length of body 1·07; length of carapace in middle ·56; breadth ·46; length of carina ·33; length from front end of carina to front edge of carapace ·23; length of caudal stylets ·75; diameter of egg-sac ·24 inch.

Thirteen specimens from "Matamoras, General Couch" and "Kansas No. 5," Mus. Chicago Acad., and a specimen from Yale Museum labelled "Plains of Rocky Mts., no. 390."

Apus Guildingii Thompson, Zool. Researches, Jan. 1834, p. 108, belongs to the same section of the genus as *A. æqualis*, but the 4th branch of the 1st maxillipeds is longer than in any other species known to me, being represented as reaching almost to the end of the caudal stylets. St. Vincent, West Indies.

To the third section of the genus belongs the European species *A. cancriformis*, and the following species from North India. They differ from the North American species in the longer carapace, the smaller eyes, and round postorbital tubercle, the less spiny telson, the more hairy caudal stylets, and the larger hypostoma.

A. Himalayanus, n. sp. ♀.—Frontal doublure and hypostoma as in *A. cancriformis;* the first pair of maxillipeds are of about the same length as in *cancriformis*, but the joints are more numerous and smaller, there being 80 joints in the longest branch, while in a specimen of *cancriformis* four times larger, there are 50. The telson is longer than in *cancriformis*, but the number and arrangement of the spines is the same, as is the under side. The stylets are scarcely as long as the body, while in *cancriformis* they are considerably longer, and the fine spines are a little stouter. No. of segments beyond the hind edge of carapace 19 (in *cancriformis* 19); no. behind last pair of feet 7 (in *cancriformis* 6); length of body 1·00; length of carapace along the middle ·64; length of carina, ·45; distance from end of carina to front edge of carapace ·36; length of caudal stylets ·95; diameter of ovisac ·15 inch, ovisacs situated on the 11th pair of maxillipeds as in all the other species of the genus known to me.

"Collected from a stagnant pool in a jungle four days after a shower of rain had fallen. For five months previous to this rain there had been no rain upon the earth. Himalaya Mountains, North India, near where the Sutlege river debouches into the plains. April, 1870." Mus. Comp. Zoology, Cambridge. Two specimens.

BRANCHIPODIDÆ.

Streptocephalus Texanus, n. sp.—The male differs from *S. similis* Baird, from St. Domingo, to which it is otherwise closely allied, in the longer branch of the inferior antennæ being much longer and slenderer at tip (according to Baird's figure), while the shorter branch is much narrower. In the female the ovisac reaches to the penultimate segment of the abdomen, while according to Baird's figure it scarcely reaches to the end of the 4th segment from the end, and the second antennæ are represented as being much larger than in our species. The male organs arise from the 8th segment from the telson, and the 15th of the body; and are simple, unarmed, slender, cylindrical, very long, and curled around (in alcoholic specimens) so as to touch at their insertion. Total length, male, ·65; length of longer appendage of 2d antennæ ·17 inch; caudal stylets ·13; length of male organs when extended ·13. Female ·55 long, caudal stylet ·11; ovisac ·20 inch. "Waco, Texas. Found in the summer in the same pool as the Limnadia was taken. The pool was formed by the summer rain, and as it had passed a considerable time in a dry condition, I suppose this species appears much later, or at least not at the same time as the Limnadia." G. W. Belfrage. It also occurred in April, the females having eggs, as did those found in the summer of the year previous.

LIMNADIADÆ.

Limnadia Texana, n. sp.—Eyes double, but with the inner edges contiguous; pyriform tubercle behind them one half as large as the eye-bearing prominence; ·20 segments behind the fore-head, including the telson; 15 pairs of feet. Antennæ with 8 joints on each branch, the 7th and 8th joints subdivided each into two subjoints; the setæ slightly plumose on the basal joints. Telson with 16 fine teeth, not including the terminal acute spine. Caudal lamellæ long and slender, cultriform; under edge slightly curved, fringed with long hairs, those at the base slightly plumose; the upper edge straight; end blunt. Carapace valves rounded oval, pure white; 5 lines of growth; shells minutely dotted, the markings being coarser at the posterior end of the shell, and about the region of the adductor muscle. Length of shell ·27; breadth ·16 inch. It is much longer and narrower than *L. Americana* Morse, and with a less number of lines of growth, the latter having 18; in this respect it is much nearer *L. Hermanni* of Europe, though the shell is much narrower. Compared with Baird's figure of *L. antillarum* from San Domingo, to which our species is nearest allied, the shell is more rounded ovate at each end, being somewhat truncated. While the ends of the caudal stylets are said in *L. antillarum* to be "somewhat curved, sharp pointed and slightly serrated on upper edge," the tip in our species is blunt, smooth on the upper edge, and ends in a slight hook. *L. antillarum* is also said to have joints to the rami of the 2d antennæ, and 18 pairs of feet.

One specimen, Waco, Texas. "Quite common in many places in western Texas in the early spring. It occurs in muddy pools made after rains, and totally disappears with the first drying of the pools. As far as I have seen they are only found in the woody bottom lands and always near creeks. It occurred in the same pool as Streptocephalus." G. W. Belfrage.

Estheria Belfragei, n. sp.—Rami of the anterior antennæ with 16 joints, 17 pairs of dorsal spines exclusive of those on the telson, which are 15 in number (in *E. Mexicana* they are much more numerous) and the middle one is much larger than those near it. The spines on the telson are fewer in number and larger than Claus represents in *E. Mexicana;* caudal stylets longer and slenderer than in *E. Mexicana*, and the terminal spine is longer and slenderer, judging from Claus' figure.

Carapace valves with the umbones situated at the anterior third of the shell; dorsal edge straight behind the umbones, slightly serrate, bent rather suddenly downward at two-thirds of the distance from the umbones to the posterior end, the end being full and rounded; anterior dorsal edge slopes rapidly from the umbones, and the anterior end is full and convex. Umbones prominent and rather acute, but not oblique. About 24 lines of growth, between which the shell is coarsely punctate; from 5–8 dots (when placed in a straight line) between the lines in the central part of the shell; these punctures are reduced to a single row on the edge. Length ·30; breadth ·23; thickness ·15 inch.

It differs from *E. Mexicana* Claus (Grube's figure) from Zimapan, Mexico, in the umbones being much more prominent; in the prominent angle of the dorsal posterior edge, while there are half as many lines of growth. From *E. Dunkeri* Baird, also from Zimapan, it differs in the less numerous lines of growth; in the smaller, less tumid umbones, and the more marked angle of the posterior part of the dorsal edge. The punctures between the lines of growth are much more numerous in *Dunkeri*. Six specimens. Waco, Texas, April, G. W. Belfrage.

Estheria Morsei, n. sp.—Shell intermediate in form between *E. Caldwelli* Baird, from Lake Winnepeg and *E. Dunkeri* Baird, from Zimapan, Mexico; shell much swollen, oblong oval, of a pale horn color; umbones large, prominent, larger than in *E. Caldwelli*, and much less oblique and situated nearer the anterior end of the shell. Dorsal margin shorter than in *E. Caldwelli*, and in front of the umbones, instead of being straight and suddenly curved downward, is regularly rounded as in *E. Dunkeri*. Behind the umbones the shell is narrower than either in *Caldwelli* or *Dunkeri*; the dorsal edge sloping rapidly downward, without the well marked angle of *Caldwelli*, or the continuous, full curve of *Dunkeri*. Coarse punctures between the ribs, rather coarser than in *Caldwelli*, there being on an average 5–10 between the ribs in the center of the valve. Length ·50; breadth ·33; thickness ·24 inch. Six specimens from Dubuque, Iowa, collected by Rev. A. B. Kendig. Dedicated to Prof. E. S. Morse, who has indicated to me that the species was undescribed.

Lymnetis gracilicornis, n. sp.—This interesting form may at once be known from *L. Gouldii* Baird, recently found by Mr. E. Burgess in Cambridge, Mass., by the long slender 2d antennæ which have about 20 joints, and are much longer than in that species. The keel on the front of the head does not reach to the front edge, while in *Gouldii* it does. Shell of the same form but much larger than in *Gouldii*. Length of shell ·17, breadth ·16 inch.

Peabody Academy of Science, Salem, Mass., May 20, 1871.

ART. XV.—*On a New Difference Engine*; by GEO. B. GRANT.

THE great labor and expense involved in the construction of reliable astronomical and nautical tables by mental computation, as well as the impossibility of getting them entirely correct, suggested to Charles Babbage the idea that this work might be done almost entirely by machinery, and the machine he invented for that purpose has become famous, as one of the most complicated and costly pieces of mechanism ever contrived. The English government appropriated eighty-five thousand dollars for its construction, on the strong recommendation of a committee of the Royal Society, containing some of the most eminent men of the time, but after years of study and labor had been spent on it, the appropriations were stopped on account of the indefinite expense. Though never completed as a working machine, it proved the feasibility of the scheme.

Babbage's idea was carried out more successfully by Edward Scheutz, and the two machines constructed on his plan are the only ones ever built for this purpose. One of these was bought for the Dudley Observatory at Albany, but has been but little used. The other was built by the British government in 1862, and has since been extensively used in the calculation of life insurance tables.*

The idea of contriving a machine for calculating tables first occurred to myself while laboriously computing a table for excavation and embankment. Having never heard of either Babbage's or Scheutz's engines, I imagined it an easy matter, but gave it up in disgust after some study. Last year I heard of Babbage's engine, became interested again, and designed a machine that might possibly have worked, but I could convince nobody that it would do so, and gave it up again. About four months ago, my teacher in the Mining School, Prof. Wolcott Gibbs, asked after the design, encouraged me in my work, and the result is the design for the difference engine, which it is the purpose of this article to describe.

Though I have built no large machine, the efficiency of the design for its purpose may be considered as having been proved, as through the liberality of the superintendent of the Coast Survey, Prof. Benjamin Peirce, I have been able to build a model of small capacity, which has worked to satisfaction.

I am indebted to Mr. John N. Bachelder of Cambridge, as well as to Professors Eustis, Winlock and Whitney, of Harvard College, for encouragement and help given. Mr. Bachelder had charge of the Scheutz engine when it first came to this country, and is one of the few who have had practical experience with any machine of this class.

A short explanation of the method of differences may not be wasted on many of my readers.

If the first term of any table be subtracted from the second, the second from the third, and so on, a new table will be formed, called the first order of differences. In the same way a second order can be formed from the first, a third from the second, and ultimately an order of differences will be reached, which is constant or nearly so. For example, take a table of the cubes of the natural numbers, and forming the several orders of difference, it is found that the third order is invariably six.

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* Accounts of Babbage's engine may be found in the Edinburg Review, July, 1834, in Taylor's Scientific Memoirs, v. 3, and in the inventor's work, "Passages from the Life of a Philosopher;" short articles on the same in Tomlinson's Cyc. of the Arts and Sciences; Harper's Mag., 1865; Manufacturer and Builder, 1870; Timb's Stories of Inventors, &c. Scheutz's engine is described in "The Swedish Calculating Machine," by Charles Babbage, in "The Manufacturer and Builder," Aug., 1870, and in detail in the British patent specifications, Oct. 17, 1854, No. 2216.

Table.	1st order.	2nd order.	3rd order.
1	7	12	6
8	19	18	6
27	37	24	
64	61		
125			

It is plain that with nothing but the first terms 1, 7, 12 and 6, the table might be constructed to any extent by simple addition. A difference engine is nothing but a machine to operate this method, using several orders of differences, and a large number of decimal places.

In logarithmic, trigonometrical, and in fact in the greater number of tables, there is no constant order, but one can be found that is so nearly so, that the error of considering it exactly so will not creep into a given number of decimal places, till any required number of terms have been calculated. A fresh start must then be taken, and the table completed by a number of such operations.

This engine, like both the others, consists of a calculating and a printing part. In the printing part, the calculated results are stamped into a sheet of lead, wax or other plastic substance, from which a stereotype plate is taken for printing the table, thus avoiding constant error in copying the numbers and setting them up in type from manuscript. No description of this part is given, as it contains nothing new of importance.

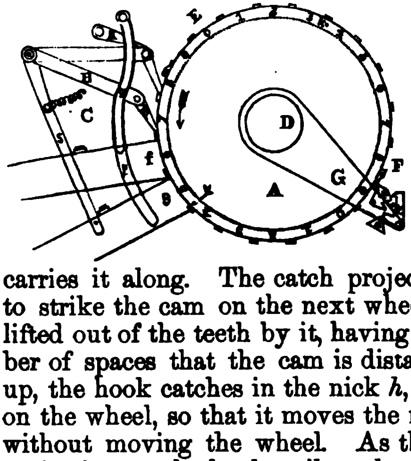
The calculating part consists of the main wheels, A, on which the first terms are set up, the additions made, and from which the calculated results are taken by the printing part; the drivers B, which make the additions, and the carrying apparatus C.

The main wheels are about one-third of an inch thick, and five inches in diameter, all turning on the same axis D, in the same direction independently of each other, the axis being stationary.

They are arranged in sets of two, three or more, according as the first, second or higher order is designed to be constant. There are as many of these sets as there are decimal places in the largest number to be used. Each wheel is furnished on one edge with twenty teeth, and on the other with two cams, a and a', which project a little farther from the wheel than the teeth. The spaces between the teeth are stamped with the ten numerals, zero to nine, twice in succession.

The first set represents the units or lowest decimal place, the next set represents the next higher decimal place, and so on. The first wheel in each set represents the corresponding decimal place of the tabular number, the second wheel, that of the first order, and the last wheel is the constant order, and is furnished only with a cam, the teeth being omitted. It can be fastened at any figure, as it never requires to be changed after once being set. By this arrangement each wheel is separated by but the sixteenth of an inch from the wheels of the same place in the next higher and next lower orders.

The point E is chosen as the point at which to read all numbers, and it is evident that any number may be shown on any order by turning the wheels till the right numbers appear at E. The cams are so arranged with regard to the numbers, that one of them shall be at the point F when the wheel reads zero. Now as the wheel is turned, as every number passes E, the cam will be moved one space further from F, so that at any time the wheel could be read as well by observing the number of spaces the cam is distant from F, as by reading the figure at E.



The drivers B are attached to the carriage G, one driver opposite each wheel except the constant ones. They consist of a catch *b* and hook *c*. The catch is pressed toward the wheel, and the hook pressed on the catch by the same spring *d*. The carriage is driven by a crank over ten spaces on the wheels, and back again, making one oscillation to every turn of the crank. As the carriage leaves the rod *e*, the catch drops between the teeth of the wheel and carries it along. The catch projects over its wheel far enough to strike the cam on the next wheel when it gets to it, and be lifted out of the teeth by it, having added to its wheel the number of spaces that the cam is distant from F. As it is raised up, the hook catches in the nick *h*, and prevents it falling back on the wheel, so that it moves the rest of the stroke and back, without moving the wheel. As the carriage comes back, the projection on the hook strikes the rod *e* and the hook is lifted out of the catch, letting it onto the wheel again.

It is necessary that while one wheel is being added to, the next wheel should not move. For this purpose the first stroke adds the first, third and odd orders to the numbers on the table, second, fourth and even orders, the odd orders being held firm by a clamp not shown. Meanwhile the rod *e* has been moved, so that the drivers belonging to the even orders are not released as the carriage comes back, but those belonging to the odd orders, so that at the next stroke the even orders are added to the odd ones, and the number on the table-wheels printed; every two strokes of the carriage giving a new term of the table.

On each wheel between the teeth and cams are two grooves. The two slips *f* and *g* rest in these grooves, being held there by light springs. The pin *k* is so arranged that, when the wheel reads nine, it will be under the first slip *f*, holding it up; and as it passes from nine to zero it drops the slip *f*, raises and drops the slip *g*. To each wheel there is an arm H, to which the catch *m* is attached, the catch resting on the teeth of the wheel. This arm would be drawn back by a spring, but is held by two catches *p* and *q*. If the catch *p* is drawn, the arm will be held by *q* only, and if *q* is then drawn it will spring back, the catch falling over the next tooth. The slip *f* of each wheel is connected with the catch *p* of the wheel of the same order in the next decimal place higher, and the slip *g* with *q*. Each arm is connected by the lever *s* with its own slip *g*, so that it will draw it out when it springs back. As each nine on the wheel A comes to the point E, the slip *f* is pushed out, and the catch *p* to the next place B drawn; and as the zero comes to E, the slip *g* is pushed out, the catch *q* drawn, and the arm over B is sprung, drawing with it the catch *q* of the next place higher, C, but not releasing the arm at C, as it is still held by *p*. *p* will, however, be drawn, if B stands on nine, and both arms sprung, as it should be, for if the arm over B is released it indicates that one is to be added to it, and if it is already nine the addition of that one will make it necessary to carry one to C also. If C is nine, one must be carried to D, and so on; one must be carried to the first wheel which is not nine.

This is all done during the addition, after which and during the return of the carriage, the cam K brings all the arms back that are up, adding one to each wheel whose arm is up.

The entire printing part, as well as some details of framing, gearing, etc., are omitted from the accompanying sketch, which is meant merely as an outline drawing showing the principal parts only.

The size of a completed machine would vary with the capa-ity. An engine of the same capacity as that of Scheutz, ld be three feet long, twelve inches high, and eight inches The cost is estimated at from two to three thousand

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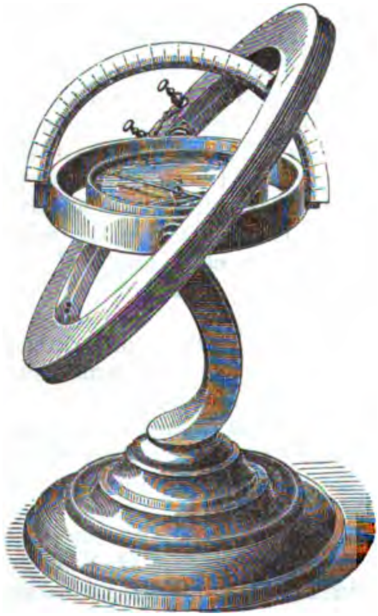
dge, June 5, 1871.

ART. XVI.—*A New Form of Galvanometer;* by JOHN TROWBRIDGE, Assistant Professor of Physics, Harvard College.

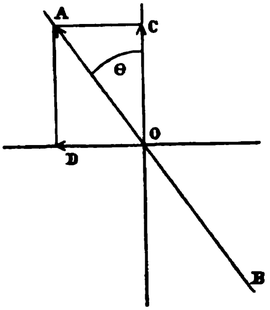
IN the tangent galvanometer the plane of the coil standing perpendicularly to the plane in which the needle moves, the needle is deflected by the action of the current passing through the coil upon the current circulating in the magnet; the magnet being considered a solenoid according to Ampère's theory. The tangent of the deflection measures the intensity of the current. The defects of the tangent galvanometer are well known. The poles of the needle in being repelled are removed from the field of the current and consequently with currents of great intensity the tangents are not closely proportional to the strength of the currents; the delicacy varying as the differential of $I = \tan \vartheta$, or $\frac{dI}{d\vartheta} = \sec^2 \vartheta$. When the ratio of the length of the needle to the diameter of the coil is a very small fraction, the tangents, however, are closely proportional to the corresponding intensities.



In Gaugain's galvanometer where the plane of the current is placed at a short distance from the axis of the needle, the intensities are directly proportional to the tangents of the deflections.

A mathematical investigation of the effects of electric currents on the magnetic needle, the plane of the current having different obliquities with regard to the horizontal plane in which the needle moves, led me to devise the following form of galvanometer:

A magnetic needle is placed at the centre of a circular current, the plane of the current at first being horizontal. In this position the needle is unaffected by the current, and is acted upon merely by the earth's magnetism. We now turn the plane of the current about a horizontal axis passing through the center of the needle as in the figure; A B representing the plane of the coil in its new position, inclined at an angle of $90^\circ - \vartheta$ to the horizon.



It will be readily seen that if A O represents the intensity of the current passing through the coil, O C will be the component that will deflect the needle; but $OC = AO \cos \vartheta = I \cos \vartheta$. The intensities will therefore be proportional to the cosines of the inclination of the plane of the current, measuring the angle from the vertical O C.

The instrument with which I experimented had the following dimensions: The diameter of the circle around which the current passed was twelve inches, and the length of the needle 1·4 inches; it was provided with long aluminum pointers. The inclinations of the plane of the current were read from a vertical scale perpendicular to both the plane of the current and to the plane in which the needle moved.

The manner of experimenting was as follows: The resistance of the battery—one Daniell's cell—having been determined with care, and also the resistance of the circuit, the instrument was first used as a tangent galvanometer with the plane of the current vertical.

Resistances from one up to ten ohms were introduced into the circuit, and the deflections noted; then with a constant resistance the angle was noted through which it was necessary to turn the plane of the current until the same deflection of the needle was obtained as in the cases where the instrument was used as a tangent galvanometer with varying resistances.

The following table gives the results obtained:

Ratio of Intensities	Angles of Deflection.	Ratio of Tangents.	Error.	Angles of Inclination.	Ratio of Cosines.	Error.
·076	$\frac{18^\circ\ 30'}{75^\circ\ 52'}$	·090	·014	$\frac{85^\circ\ 30'}{0^\circ}$	·078	·002
·142	$\frac{32^\circ\ 15'}{75^\circ\ 52'}$	·158	·016	$\frac{82^\circ}{0^\circ}$	·139	·003
·200	$\frac{41^\circ}{75^\circ\ 52'}$	·226	·026	$\frac{78^\circ\ 45'}{0^\circ}$	·195	·005
·333	$\frac{54^\circ\ 35'}{75^\circ\ 52'}$	·354	·021	$\frac{70^\circ}{0^\circ}$	·342	·009
·400	$\frac{15^\circ}{32^\circ}$	·428	·028	$\frac{65^\circ}{0^\circ}$	·422	·022
·529	$\frac{14^\circ\ 30'}{25^\circ\ 30'}$	·542	·013	$\frac{57^\circ}{0^\circ}$	·544	·015.
·692	$\frac{18^\circ\ 30'}{25^\circ\ 30'}$	·701	·009	$\frac{47^\circ\ 45'}{0^\circ}$	·672	·020
·810	$\frac{21^\circ\ 30'}{25^\circ\ 30'}$	·825	·015	$\frac{38^\circ\ 15'}{0^\circ}$	·785	·025

It will be noticed that with large deflections the ratio of the cosines is nearer the ratio of the intensities than the ratio of the tangents. With smaller deflections, however, the ratio of the tangents is nearer that of the intensities than the ratio of the cosines. In the expression $I\cos\vartheta = CO = \tan\vartheta'$,

or $I = \frac{CO}{\cos\vartheta} = \frac{\tan\vartheta'}{\cos\vartheta}$, if we differentiate I with respect to ϑ we obtain

$$\frac{dI}{d\vartheta} = \frac{\cos\vartheta \frac{d.\tan\vartheta'}{d\vartheta} + \sin\vartheta\tan\vartheta'}{\cos^2\vartheta}$$

It will be seen that the delicacy varies inversely as the cosine of the inclination decreases, or in other words, as the angle of the plane of the current with the vertical increases; the vertical component of the intensity increases while the horizontal component decreases. This vertical component thus renders the needle less sensitive to the horizontal component and dips it. By diminishing the length of the needle, and providing it with long pointers, and also increasing the diameter of the circle around which the current passes, the effect of the vertical component can be lessened.

With large deflections, therefore, this instrument appears to give closer results than the tangent galvanometer; and therefore supplies a deficiency in the latter instrument. By the cosine galvanometer many determinations of the intensity of the same current can be made by forming a table of the values of the cosines of different angles of inclinations in terms of the deflections of the needle, which currents, with a known resistance interposed produce. In the tangent galvanometer but one determination can be made.

Irrespective of the accuracy of this method, the instrument can be viewed as supplying a break in the literature of the subject. We have now in addition to the tangent galvanometer and the sine galvanometer, a cosine galvanometer.

My thanks are due to Prof. Cooke, of Harvard College, for the generous use of his apparatus for electrical measurements.

ART. XVII.—*Notice of some new Fossil Mammals and Birds, from the Tertiary Formation of the West;* by O. C. MARSH.

IN addition to the species of extinct Mammals described in the last number of this Journal, page 35, the Yale party, during their investigations in the Rocky Mountain region, discovered several others of interest, which are here briefly characterized. The remains of a number of fossil Birds were also found, and a preliminary notice of the more important specimens is included in the present article.

Arctomys vetus, sp. nov.

Remains of Rodents are very rare in the Green river Tertiary basin, although not uncommon in the more recent strata, east of the Rocky Mountains. A small species of the genus *Arctomys*, represented by a nearly perfect lower jaw, and other remains, was discovered during our explorations on the Loup Fork river. This species was only about one-third the size of the modern *Arctomys monax* Gm., and may at once be distinguished from that rodent by the lower incisors, which have on the anterior surface a shallow median groove. The molar teeth of the lower jaw have essentially the same composition as those of the larger species.

Measurements.

Length of lower jaw from condyle to base of incisor,	17·75	lines.
Antero-posterior extent of four lower molars,........	6·5	"
Depth of lower jaw below first molar,...............	4·5	"

The specimens on which the species is based, were found by Mr. J. W. Wadsworth and the writer, in the Pliocene beds, on the Loup Fork, in northern Nebraska.

Geomys bisulcatus, sp. nov.

Another extinct Rodent, about the same size as the preceding species, is indicated by several fragments of jaws and teeth, found in the same Pliocene Tertiary beds. The incisors of the lower jaw in this species have the anterior face broad and flat, with the external angle acute. They extend backward under the entire molar series. The latter has a very similar composition to the molars of the recent *Geomys bursarius* Shaw, and the two species may eventually prove to be nearly allied. The upper incisors, likewise, are similar. On their anterior face there is a deep, rounded groove, with its lowest part just outside the median line. Near the inner angle, also, of each incisor, there is a second, very fine, sharp groove. The external front angle is rounded, and the lateral face but slightly convex. The premaxillary suture forms externally an obtuse angle, with the apex forward, near the posterior face of the incisor. In both jaws, the incisors are deeper than wide.

Measurements.

Transverse diameter of upper incisor, ...	1·6	lines.
Antero-posterior extent, ...	2·	"
Depth of skull at premaxillary suture,.................	6·	"
Length of lower incisor on arc of curve,..............	15·	"
Tranverse diameter at apex, ...	1·5	"
Depth of lower jaw below first molar,.................	5·6	"
Antero-posterior extent of first three lower molars,.....	3·5	"

The only known specimens representing this species were found by the writer in the Pliocene strata, near Camp Thomas, on the Loup Fork river.

Sciuravus nitidus, gen. et sp. nov.

A very small extinct rodent of much interest is indicated by a portion of a left upper jaw, enclosing the last three molars, which was one of the treasures secured by the Yale party last autumn in the Tertiary beds of the Green River basin. The teeth preserved have apparently a near resemblance to those of the *Sciuridæ*, and hence the present fóssil may be referred provisionally to that group. The genus is apparently distinct from any known, and will be more completely defined in the full description. The upper molars are composed essentially of two pairs of tubercles, with a minute intermediate cone on the outer edge. There is a strong basal ridge in front, and the inner margin is bifid. The species was about the size of the common brown rat, *Mus decumanus*.

Measurements.

Length of part of upper jaw, enclosing the three posterior molars,	3·4	lines.
Antero-posterior extent of antepenultimate upper molar,	1·	"
Transverse extent of same,	1·	"

This unique specimen was discovered by the writer at Grizzly Buttes, near Fort Bridger, Wyoming.

Sciuravus undans, sp. nov.

The present species was somewhat larger than the preceding, but probably a near ally. A single specimen only can now with certainty be referred to it, and a discussion of its exact affinities must be reserved for another occasion. The fossil in question is part of a right lower jaw containing the incisors and first three molars, all in excellent preservation. The incisor extends below the entire molar series. Its anterior surface is smooth, and somewhat convex, and the inner face, where the two teeth meet, is marked by a succession of delicate wave-like impressions. The tubercles of the molars are more prominent than in those of the last species.

Measurements.

Length of portion of lower jaw, containing first three molars,	3·5	lines.
Transverse diameter of third lower molar,	1·	"
Transverse diameter of lower incisor,	·6	"

This specimen was found by the writer at the same geological horizon, and near the same locality that afforded the species last described.

Triacodon fallax, gen. et sp. nov.

A small extinct mammal of much interest, is indicated by a premolar tooth, and possibly by some additional remains, collected in the lower Tertiary beds of Wyoming. The tooth appears to be the last premolar of the right lower jaw, but differs so widely from the corresponding premolar in any known species, as to render the nature of the animal to which it belonged more or less uncertain. The crown is triangular at the base, the outer and longest side being somewhat convex, and the other two nearly flat. The upper surface is composed of three triangular tubercles, one at each angle, the anterior being much the highest, and the inner one the smallest. This peculiar tooth resembles slightly the corresponding premolar in some of the Insectivores, and is likewise similar in some respects to those of certain Marsupials, but further remains will doubtless be necessary to determine its true zoological position. The present species was probably about two thirds the size of the North American opossum.

Measurements.

Antero-posterior diameter of lower premolar,..........	2·25	lines.
Transverse diameter of same,.......................	1·95	"
Height of anterior tubercle,........................	2·8	"
Height of posterior tubercle,.......................	1·6	"
Height of inner tubercle,...........................	1·75	"

All the specimens supposed to pertain to this species were found by J. M. Russell and the writer, at Grizzly Buttes, near the base of the Uintah Mountains.

Canis montanus, sp. nov.

The presence of a large Carnivore in the fossil fauna of the Green River Tertiary basin, which could with comparative certainty be predicated upon the discovery there of so many extinct pachyderms, was clearly established by our party; although the evidence at present rests on remains more or less fragmentary. Those already known consist of a last upper premolar tooth in good preservation, a Canine, wanting most of the crown, and a number of the larger bones of a skeleton, all apparently of the same species, but pertaining to three individuals, differing somewhat in size. These various remains indicate an animal considerably larger than the recent Gray Wolf (*Canis occidentalis*), and one probably belonging to the same family. The last upper premolar in the present extinct species is robust, has a short compressed crown. The principal cusp is conical, with sub-acute edges, the anterior being about twice the length of the posterior. Behind the main cusp there is a large triangular tubercle, with its apex exterior to the fore and aft axis of the crown. In the canine tooth, the base of the crown forms a broader oval than in most of the recent *Canidæ.*

Measurements.

Antero-posterior diameter of last upper premolar,	9·	lines.
Greatest transverse diameter of same,	4·25	"
Height of main cusp,	6·	"
Height of posterior tubercle,	3·75	"
Antero-posterior diameter of canine at base of crown,	7·	"
Transverse diameter of same,	5·	"

The above specimens were found by H. B. Sargent and the writer, at Grizzly Buttes, Western Wyoming.

Vulpavus palustris, gen. et sp. nov.

A second, much smaller carnivore is indicated by several upper molar teeth, and other fragmentary remains, found during our explorations in the same Tertiary deposits that yielded the preceding species. The specimens belonged to several individuals, all considerably smaller than a fox, and apparently having some affinities with that animal, although generically distinct. One of the best preserved of the teeth is a second, right, upper molar, which has a similar composition to the corresponding tooth of the common Red fox (*Vulpes fulvus* Desm.), but differs in the outline of the crown, which has the posterior side the longest, thus indicating a relative greater expansion at this part of the skull. The first upper molar, also, has a proportionally less fore and aft extent than the same tooth in the fox.

Measurements.

Length of portion of jaw containing last three upper molars,	10·5	lines.
Antero-posterior diameter of second upper molar,	2·35	"
Transverse diameter of same,	4·	"

The specimens now representing this species were discovered by Dr. J. V. A. Carter, and the writer, near Fort Bridger, Wyoming.

Amphicyon angustidens, sp. nov.

Another extinct carnivore, about as large as the preceding species, and perhaps related to the same group, is represented by the anterior portion of a right lower jaw, containing the last three premolars, and the canine. The ramus is slender, but rather deep. The premolar teeth are low, and unusually compressed. All have a distinct tubercle in front of the main cusp, and the third and fourth have the posterior edge trifid. The present specimen agrees essentially in size with the corresponding jaw of *Amphicyon gracilis* Leidy, but the last premolar is less elevated, more compressed, and has the middle tubercle on the posterior edge much less developed than in that species.

Measurements.

Length of part of lower jaw containing four premolars,	9·5	lines.
Depth of jaw below last premolar,	5·	"
Width of jaw below last premolar,	2·1	"
Antero-posterior diameter of last lower premolar,	3·	"
Transverse diameter of same,	1·25	"
Height of crown,	1·8	"

This species was found by the writer, in the Miocene Shale, at Scott's Bluff, on the North Platte river, Nebraska.

FOSSIL REMAINS OF BIRDS.

Since the beginning of the last year, when the first fossil Birds from this country were described by the writer,* but two additional species have been announced: an extinct Turkey, *Meleagris altus* Marsh (*M. superbus* Cope), from the Post-Tertiary of New Jersey,† and a Gannet, *Sula loxostyla* Cope, from the Miocene of North Carolina.‡ A special search was made by the Yale party last season for Bird remains, and a number of specimens were discovered, most of which were not sufficiently well preserved to admit of accurate determination. The few described below, although imperfect, are quite characteristic, and form an acceptable addition to the rich Tertiary fauna of the West, which has so long been deemed wanting in remains of this class.

Aquila Dananus, sp. nov.

An extinct species of Eagle, nearly as large as the modern Golden Eagle (*Aquila Canadensis* Cass.), is indicated by the distal portion of a left tibia, discovered during our explorations in the Pliocene beds of the Loup Fork river. The specimen shows, at its lower extremity, the peculiar fore and aft flattening, and the oblique, tapering supra-tendinal bridge over a deep canal, so characteristic of the recent birds of prey belonging to this genus. From the tibia of the Golden Eagle, evidently a nearly related species, the present fossil may readily be distinguished, aside from its inferior size, by the less concave inferior and posterior trochlear surfaces, and by the more prominent and well defined tubercle at the center of the ento-condyloid surface.

Measurements.

Width of condyles in front,	8·	lines.
Antero-posterior diameter of inner condyle,	5·25	"
Antero-posterior diameter between condyles,	3·3	"
Transverse extent of outlet of canal below bridge,	2·	"

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* This Journal, vol. xlix, p. 205, 1870.

† Proceedings Philadelphia Acad. Nat. Sciences, 1870, p. 11, and American Naturalist, vol. iv, p. 317.

‡ Synopsis of Extinct Batrachia, &c., p. 236.

This unique specimen was discovered in July last by Mr. A. H. Ewing, in a Pliocene bluff on the Loup Fork river. The species is named in honor of Professor James D. Dana.

Meleagris antiquus, sp. nov.

A large Gallinaceous Bird, approaching in size the wild Turkey, and probably belonging to the same group, was a cotemporary of the *Oreodon* and its associates, during the formation of the Miocene lake deposits east of the Rocky Mountains. The species is at present represented only by a few fragments of the skeleton, but among these is a distal end of a right humerus, with the characteristic portions all preserved. The specimen agrees in its main features with the humerus of *Meleagris gallopavo* Linn., the most noticeable points of difference being the absence in the fossil species of the broad longitudinal ridge on the inner surface of the distal end, opposite the radial condyle; and the abrupt termination of the ulnar condyle at its outer, superior border.

Measurements.

Greatest diameter of humerus at distal end,	12·	lines.
Transverse diameter of ulnar condyle,	3·4	"
Vertical diameter of same,	4·	"
Transverse diameter of radical condyle,	4·25	"

The specimens on which this species is based were discovered by Mr. G. B. Grinnell, of the Yale party, in the Miocene clay deposits, of Northern Colorado.

Bubo leptosteus, sp. nov.

Several imperfect specimens of bird bones were found in the early Tertiary beds of the Green river basin, only one of which, however, the distal half of a left tibia, is sufficiently characteristic to suggest the near affinities of this species to which it pertained. This specimen shows that the tibia, when entire, was a slender, nearly straight bone, much compressed in an antero-posterior direction at its distal end, and having similar proportions to the same bone in the *Strigidæ*, or Owl family. The near resemblance is rendered especially striking by the entire absence of the osseous supra-tendinal bridge, which is wantin this group, and in a few other birds with which the present species is apparently less nearly allied. The fossil under consideration would indicate a species about two-thirds the size of the Great Horned Owl (*Bubo Virginianus* Bon.), the tibia of which it resembles in nearly all essential particulars. There is, however, no trace of a fibular ridge on the outer surface of the distal end, as in that species, or on the portion of the shaft preserved; which would seem to imply a generic difference between the two forms, and additional material will doubtless prove such to be the case.

Measurements.

Length of portion of tibia preserved,	15·	lines.
Width of condyles in front,	6·5	"
Transverse anterior diameter of inner condyle,	2·5	"
Transverse anterior diameter of outer condyle,	1·8	"

This specimen, the only known representative of the species, was found by the writer last autumn at Grizzly Buttes, near Fort Bridger, Wyoming.

Yale College, New Haven, June 12th, 1871.

ART. XVIII.—*Notes on the distribution of the Vegetation of Santo Domingo;* by W. M. GABB.

MUCH has been said and written on the singular phenomenon, exhibited on a grand scale in our western prairies as well as in South America and elsewhere, of large treeless areas, strongly circumscribed, and covered with grass. Innumerable theories have been advanced to account for the absence of forest growths over these tracts, and the entire absence of even isolated trees has been a cause of unlimited speculation. This is the more strange since it is found that when trees are artificially planted, they flourish, and the occupation of these tracts in the Mississippi region is covering them with vigorous groves.

Upwards of two years of residence in "the garden of the Antilles" has given the writer an opportunity of studying the matter here, as well as of making some general observations on the distribution of the vegetation of Santo Domingo.

To most persons who have never been in the tropics, the term presents a vision of tangled jungles, endless climbing vines, and waving palms. Few think of broad swelling prairies and smiling meadows as compatible with a landscape below the Cancer. But both exist in charming variety, not only in the favorite home of Columbus, but over much of our little known neighbor, the continent of South America.

On the Island of Santo Domingo, the grass and tree regions are sharply defined, and correspond in the main with certain geological features. First, the whole mountain region is covered with tree-growth to at least a little distance beyond its base. Second, the valley of the Cibao, the great valley occupying a fourth of the Republic of St. Domingo proper, and running east and west on the north side of the Island, is in the main a tree region, with scattered savannas, as will be described farther on. Third, the south side of the island, outside of the mountain tracts, is nearly equally divided between forest and prairie.

Observation proves that in each and every case the relation between the soil and its growth is constant. The mountains are composed of easily decomposable rocks, which produce a rich soil. This supports dycotyledonous trees of an infinitude of species, with a dense undergrowth in which climbing vines, some with trunks three and four inches thick, are the most marked feature. But there are tracts, more especially on the northern flanks of the range, where the soil is a red gravel. Here, without reference to altitude, (except that it does not extend into the plains) the forest growth is coniferous—a tall slender species of long leaved pine, and invariably, under the pines is a scattered growth of grass. The only other marked effect of altitude on the vegetation in these mountains is the almost invariable existence, above a height of say 2500 to 3000 feet, of dense thickets of a tall slender fern, which renders the higher peaks almost absolutely inaccessible.

The Tertiary rocks, which constitute the Cibao valley and northern range of mountains, never carry pine. The eastern half of the valley is covered in part with a very deep black mould, always bearing dense forests, and with a gravelly or clayey soil always covered with grass. This valley lies directly in the course of the trade winds; its eastern end, at Samaná bay, being open like a funnel to draw in the moisture-laden breezes from the Atlantic. As the current draws down the valley, confined by the hills on both sides, it deposits its vapors so liberally in the Vega, or eastern end, that by the time it reaches the middle of the valley, it is perceptibly dryer. The inevitable result is a striking change in the vegetation. The soil, which in the mountains would be pine lands, or in the Vega would make of this one continuous savanna of fifty miles long, here bears a straggling growth of low Acacias and Cacti. Among the latter, a Cereus of twenty to thirty feet high and an arborescent Opuntia often twenty feet high, are the most marked. In the more fertile soil, both on the lower hills and in the valley, lignum vitæ (Guayacan) abounds, and logwood (Campeachy) frequents the moist bottom. Throughout the Cactus and Acacia tracts, grass grows sparsely.

The mountains approach the coast, west of Santo Domingo city, leaving small plains only, until near the great bay of Ocoa. East of this broad spur is a strip of plains nearly thirty miles wide extending to the eastern end of the island. The underlying geology, and consequently the surface soil, is here divided into two well marked groups. In the Post-pliocene era, the coast line followed the present mountain base, and the mouth of the Jaina river was twenty-five or thirty miles farther northwest than at present. This stream runs through a region of hard rocks; and its débris, now spread over the country like a fan, is consequently a coarse gravel, gradually changing into a clay or sand, as the distance from the old mouth and coast line increases. Still further, where shore influences fade out, the same strata are continued, but instead of appearing as a loose gravel, they become calcareous, and, in the then deep sea, change to beds of coral limestone.

The underlying gravels sands and clays are always covered with grass while the calcareous rocks make, as invariably, a tree region. In consequence of this, the whole coast, for a width of about ten miles near St. Domingo city, and gradually becoming wider eastward, is a great forest covering about two thirds of the plain. Mahogany grows only on calcareous soils, and this is thus the great mahogany-producing region of the Republic. It also abounds in logwood.

The same condition of the winds, though in a less degree than in the north, exists on the south side. Saybo is a rainy region, Azua is dry. About thirty miles west of Sto. Domingo, the region of cactus begins, the acacias straggling ten miles farther east. With the above mentioned species of Cereus and Opuntia, a small Echinocactus is most common here. Here again reappears the lignum-vitæ with considerable quantities of fustic.

I have not had an opportunity of examining the region northwest of Azua, which is infested by roving bands of Haytian marauders, but from the meager information I have been able to obtain, I am led to infer that there, there is no marked variation from the general rule of the rest of the country.

Throughout all the savannas, whether on the north or south side of the Island, almost every depression, and every watercourse is marked by its clump or line of trees; the spots being equally characterized by a richer soil, brought there by the surface drainage of rain waters. This, in connection with the other facts stated above, points to the inevitable conclusion, that the richer soils produce forest, and the poorer, grass growths. Independent of the tendency in the trees to monopolize the richer soil and kill out the grass by their shade, there comes in to the aid of the humble growths an important agency, which prevents or retards the spread of the forests which would otherwise inevitably overrun all the grass land in the end. This agency is fire. The edges of the tree tracts are as sharply defined as if attended by a careful gardener. The annual fires so scorch and burn up the smaller bushes, the advance guards of the larger trees, that it is doubtful, in the process of encroachment, which has the advantage.

ART. XIX.—*Brief Contributions to Zoölogy from the Museum of Yale College.* No. XV.—*Descriptions of Starfishes and Ophiurians from the Atlantic coasts of America and Africa;* by A. E. VERRILL.

THE genus, *Goniaster*, as restricted by Dr. J. E. Gray in 1840, includes several beautiful species of starfishes, which are still very rare and imperfectly known. Dr. Gray named three species, without giving descriptions sufficient for their identification, all of which were from unknown localities, and two of them were apparently known to him only from the rude figures of Linck and Seba. I am unable to refer the two following species to either of the species named by him.

Goniaster Americanus, sp. nov.

Form pentagonal with deeply and regularly concave edges. Radii as 1 : 1·8. Rays considerably less than half the diameter of the disk, triangular, tapering, with slightly incurved sides. The disk is somewhat convex, especially at center, and covered with rather large, polygonal plates, which are separated by lines of pores, and on the rays by small groups and circular clusters of granules. The plates, unless supporting a spine, are closely covered with small polygonal granules, with a well-marked larger series around the edge; those that bear spines have the marginal granules and two or more series of the smaller ones around the base of the spine. In the center of the disk is a single spine, around this are five larger ones, each of which is the first in a row of 4 to 8 spines extending along the middle of the ray, but usually interrupted by plates destitute of spines; bordering the middle of the central row, on each side, there is a row of 5 or 6 similar spines; outside of these a row of 3 or 4 smaller spines; and beyond these usually 1 or 2 spines; thus the middle region of each ray has a broad-oval group of spines, broadest toward the center of the disk.

The groups of spines are separated by depressed interradial zones, destitute of spines; in each of these there is a rounded plate, outside of and alternating with the spines of the central pentagon; beyond these there are, in four of the zones, a pair of rather large plates, in contact by their straight inner margins; in the fifth zone a large convex madreporic plate takes the place of these. The upper marginal plates are 14 to each interradial margin, about as long as broad, very convex, the three median ones largest, and rising into two blunt tubercles or spines, which are united at base; most of the others, except the penultimate ones, bear a single, conical, blunt tubercle, decreasing in size toward the end of the ray. Lower marginal plates 22 to each margin, the median ones smooth, convex, nearly twice as high as wide, the lateral edges straight and in contact; those toward the ends of the rays become rounded, about as broad as high, and the last four or five plates bear single, stout, blunt tubercles. The marginal plates are surrounded by either one or two rows of granules. The plates of the lower surface are closely covered with polygonal, round-topped granules, smallest toward the edges of the plates; a few plates near the mouth bear one or two stout central tubercles; others near the ambulacral grooves, and especially toward the margin, have a smooth central area, perforated by one or more small pores and bearing as many peculiar pedicellariæ, which consist of two, slender, spatulate, or spoon-shaped blades, often curved laterally, and usually seen widely open, when they are received into grooves or pits in the plate, exactly fitted to their forms. Similar pedicellariæ of smaller size exist at the base of many of the dorsal spines.

The interambulacral plates bear, at their inner edges, a row of about 4, prismatic, nearly equal, blunt, spines; and outside of these an irregular crowded group of 4 to 6, stouter, but scarcely longer, blunt spines, the outer ones shorter; these form three or four irregular rows.

Radius of disk 1·45 inches; of rays 2·60; length of largest dorsal spines ·30; diameter ·20 of an inch. Color of the dried specimen yellowish brown, when fresh bright red.

Off Charleston, S. C., from the mouth of a Black-fish,—Prof. C. U. Shepard.

Goniaster Africanus, sp. nov.

Depressed, pentagonal, with shorter rays and less concave edges than the preceding species. Radii as 1 : 1·6. Rays broad triangular, obtuse, the last upper marginal plates larger than the others and more swollen. Plates of the upper surface smaller and more numerous than in the preceding, and more coarsely and irregularly granulated. Spines smaller, but much more numerous, the clusters scarcely separated and covering most of the surface; the median row of the rays, with 10 to 12 spines; the first laterals with about as many; the second laterals with 5 or 6; the third, with 3 to 5. Upper marginal plates 10 to each interradial margin, smooth, convex, the median ones narrowest, higher than broad; the last one largest, rounded, very convex; none bear spines or tubercles. Lower marginal plates 18 to each margin, smooth, convex, destitute of tubercles, except occasionally a minute one on some of the last plates. Ventral plates covered with very unequal rounded granules, those on the central part much larger than the others, in the form of small round tubercles. No pedicellariæ observed. Interambulacral spines arranged much as in the preceding, but more slender and less numerous, the outer ones forming two or three rows.

Radius of disk 1·06; of rays 1·70; length of longest spines ·17; diameter ·12 of an inch. Color of dried specimens light orange-red.

West Coast of Africa,—Capt. W. W. Hall. Received from the Peabody Academy of Science, Salem, Mass.

Amphipholis abdita, sp. nov.

Disk small; arms much elongated, about 12 times the diameter of the disk, of nearly uniform diameter throughout the greater part of their length.

Six mouth-papillæ in each angle of the mouth, and two to four additional small rounded papillæ, or tentacle scales, near the extreme outer angle. Two of the mouth-papillæ on each side are placed close together, at about the middle of the edge of the jaw; the outer of these, which is about twice as wide as the inner, is flat, scarcely longer than wide, with the end obtusely rounded or truncate; the inner one is scarcely wider than thick, oblong, rounded at the end; in one case these two papillæ are united together. The third mouth-papilla is stout and rounded, obtuse, larger and longer than either of the others, separated from them by a considerable interval, and brought close to the tooth at the end of the jaw, beyond which it projects inwardly and downwardly.

The mouth-shields are long-oval, narrowed outwardly, the outer part of the lateral edges being nearly straight, the outer end rounded, the inner end broadly rounded. Side mouth-shields triangular with the three edges concave, the inner ends not united, the surface finely granulated. The lower arm-plates are separated by the side plates; the two first are longer than broad, pentagonal, the inner end forming an obtuse angle, the outer edge straight; the two next are about as wide as long, squarish, with the corners rounded or truncate; the following ones are broader than long, somewhat octagonal, the outer and inner edges longest and nearly straight; beyond the middle of the arm they are again pentagonal, with an inner angle. On the first five joints there is usually only a single pair of tentacle-scales, which are small and rounded; on the succeeding joints there are generally two pairs, one of them being considerably smaller than the other.

Arm-spines three, on all the joints except the first, which has but two; they are thickened at base, gradually tapering, blunt at tip, subequal, the lower ones a little curved downward; length about equal to width of lower arm-plates. The upper arm-plates are transversely subelliptical, with the outer edge well rounded, the inner edge slightly prominent or angular in the middle, and a little concave to either side, so that the lateral portions are somewhat narrowed; the plates generally touch each other, but scarcely overlap, unless close to the base of the arms. The upper surface of the disk has been destroyed in the only specimens seen. Diameter of disk about ·38 of an inch; length of longest arms (broken at the ends) 4 inches.

Color in alcohol uniform light yellowish, when living tinged with greenish.

Off Thimble Islands and Savin Rock, near New Haven, in 3 to 6 fathoms, muddy bottom, living buried in the mud with one arm thrust out of its burrow.

I have been aware of the existence of this species for several years, having on several occasions dredged a single detached arm, but it was not until last autumn that I succeeded in obtaining a specimen with the disk, and even in this the covering of the dorsal side was destroyed.

It is somewhat allied to *A. gracillima* (Stimpson), of S. Carolina, and has similar habits. The latter has more slender arms, four or five arm-spines, and different mouth parts.

Ophiophragmus Wurdemanni Lyman, Catalogue, p. 132.

This species is common at Fort Macon, N. C., living in the sand at low water, where it was obtained by Dr. A. S. Packard and Dr. Elliott Coues. It varies considerably in color, some specimens being yellow, with few dark markings; in others the dark brown bands predominate. The disk is brown above, lighter below.

The arms are very long and slender. One of the largest has the arms 6 inches long, and the disk ·4 in diameter. The scaling of the disk is variable, and generally coarser than in Mr. Lyman's type specimens. The radial shields are usually in contact. The under arm-plates, near the base of the arms, are emarginate and slightly bilobed.

ART. XX.—*Notice of the Meteoric Stone of Searsmont, Maine;* by CHARLES UPHAM SHEPARD, Mass. Prof. of Natural History in Amherst College.

FOR the particulars concerning the fall of the Searsmont meteorite I am indebted to Mr. E. B. Sheldon, postmaster of the adjoining village of Searsport, and to the Republican Journal of Belfast, Maine, of Thursday, May 25th.

Mr. Edward Burgess of Searsmont furnished the short notice contained in the newspaper. He states that the fall took place in the southern part of the town, at about 8 o'clock on Sunday morning, the 21st instant. "There was first heard an explosion, like the report of a heavy gun, followed by a rushing sound resembling the escape of steam from a boiler. The sound seemed to come from the south, and to move northwardly. The stone fell in the field of Mr. Bean, the flying earth being seen by Mrs. Buck, who lives near. The hole that it made was soon found and the stone dug out. It was quite hot and so much broken as to be removed only in pieces. The outside shows plainly the effect of melting heat. It struck with such force as to penetrate the hard soil to a depth of two feet."

The following is the substance of Mr. Sheldon's letter. Mr. Luce, who dug the stone, tells me he reached the spot about fifteen minutes after it struck, when he found the fragments still quite warm. The largest piece weighed two pounds. All together, the pieces amounted to twelve pounds. They emitted the odor given off by stones violently rubbed together. The hole produced by the descent was vertical in its direction, and two feet in depth. The character of the soil was a hard, coarse gravel; and the shattering of the stone was produced by its finally meeting three large pebbles, (each about four pounds in weight) in the course of its descent. "Mrs. Buck, who saw it fall, or rather saw the scattering of the soil on its entering the ground, was reading at the time in the house, distant about thirty rods from the spot. The time was 15 minutes past eight. She first noticed a report about as loud as that of a heavy gun, or of a rock-blast, such as they hear from a lime-quarry situated about a quarter of a mile distant. This was followed by a rumbling noise, as of a number of carriages passing over a bridge. She rose and looked out from a back door, then re-crossed the room to the front door, where, after the lapse of about ten seconds, she saw the dirt in motion from the contact of the stone with the earth. She thought it must have been nearly two minutes from the first report, until the stone struck the ground. No one went to the place for 20 or 25 minutes. The report was heard in Warren, twelve miles to the southwest; likewise a hissing sound as of escaping steam. No report or sound was heard in Searsmont village, three miles to the northeast."

Through the kind assistance of Mr. Sheldon, I am in possession of the largest remaining mass of this meteorite. Its weight is two pounds. Fully one-half of its surface is coated with the original crust. Its shape would seem to denote an oval, subconical figure in the original mass, with a flattish base, so as on the whole to have approached the shape of the famous Duralla (India) stone, (Feb. 18, 1815), now preserved in the British Museum.* The coated part of my specimen, which corresponds to a portion of what constituted the base of the supposed cone, differs in shape and color from the two oval undulating sides, which make therewith angles of between 60° and 70°. The broadest of these sides (above three inches in length) where it meets the base, forms a blunt rounded edge, is obscurely striated vertically to the intersection, and shows a slight thickening about the edge, as if matter had been swept over from above and accumulated somewhat on the under side. Nothing is plainer than the distinction in character between the upper sides and the base. The crust of the latter is perfectly black, more thoroughly fused, with a blebby, somewhat glassy, reticulated surface, whose lines are without any order; while the upper surfaces are more even and almost destitute of the blebby and veined appearance. Feeble striæ are visible near the basal side, all of which are perpendicular to the same. The color of the upper surfaces is brownish black; and these are wholly without luster.

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* Of which I possess an excellent model, presented me while that stone was still in the collection of the East India House.

The thickness of the crust is more than double that found in any stone belonging to my collection,—amounting at least to one-sixteenth of an inch. The stone is rather below the average in respect to frangibility. The color is bluish-white, and remarkably uniform, except from feeble stains of peroxide of iron, and from silvery white, metallic points, produced by the meteoric iron. More than half the stone is in the form of rounded grains, mostly with roughened or drusy surfaces, and of a size rarely exceeding mustard seeds. Between these, and often partially coating them, is a fine grained subcrystalline white, or grayish-white mineral, which I take to be chladnite. It is rather loosely coherent, and without visible crystalline structure. Indeed, as seen by the microscope, it is often porous, reminding one of the siliceous skeletons obtained in fluxing certain silicates in blowpipe experiments. This white mineral may form a quarter or more of the stone.

The rounded globules are bluish-gray, rarely with a faint tinge of yellow, vitreous in luster and translucent, with two imperfect oblique cleavages. On the whole, they resemble the unaltered grains of boltonite more than any of our terrestrial minerals; and differ only in their greater tendency to assume the globular figure.

Minute points of bright meteoric iron are very thickly scattered through the mass. A few grains of troilite, the largest of the size of small kernels of Indian corn (maize), likewise present themselves; together with a single blackish mass of similar dimensions, which on being touched with the point of a knife was found to be soft, and left a bright metallic streak. It is probably a plumbaginous aggregate. Sp. gr. of the aggregate = 3·626.

In general character, it approaches most nearly to the stones of Quenggouk (Pegu, India) that fell Dec. 27, 1857, differing from them in having more of the fine whitish gangue, and in possessing a thicker and more blebby crust. It also presents points of resemblance to the Aussun (France) meteorite of Dec. 9, 1858; but the latter has a much thinner crust, a darker colored general basis or gangue, much larger globules, and at the same time, it is a firmer stone.

There is even an internal similarity between the Searsmont meteorite and that of Duralla. They approach each other in the thickness and general character of the crust; but the whole of the latter is darker, and the regularity in the shape of its globules is less marked.

Should I succeed in recovering a portion of the now widely scattered fragments of this interesting stone, I shall enter upon a more detailed examination of its character.

Letter to the Editors from Dr. B. A. Gould, *Director of the Cordoba Observatory, dated Cordoba, April* 26, 1871.

[Concluded from page 80.]

The magnificence of the Milky Way in this vicinity is indescribable, surpassing the Pleiades or the Præsepe in richness, and exhibiting numerous huge clusters, the sight of which through the Tolles telescope evokes exclamations of astonishment and delight from every beholder, young or old, whether with or without astronomical information. Keen as was my desire for a photographic equipment before leaving home, it has been a hundred-fold increased since I began the survey of this most gorgeous of all the regions of the sky. Even yet I have not abandoned some hope that the friends of astronomy at home may be disposed to provide means for some permanent photographic record of these magnificent groups and splendid double stars. The transparency of the atmosphere would greatly reduce the needful time of exposure, and it gives peculiar opportunities for the success of the photographic method in other respects.

The news from the Eclipse-observers—so long and anxiously expected—is just beginning to arrive; our mail facilities having been sadly interfered with by the quarantine, established at Rosario, which has for more than two months placed an absolute interdiction upon all personal communication with Buenos Aires. From such accounts of the eclipse as have yet come to hand, it would seem that the results tend to confirm the doctrine that the corona is of a composite character, although this idea met with such opposition prior to the eclipse; but that my other observation, to which I attribute a good deal of importance, viz:—the change of outline in the more conspicuous and external portion of the phenomenon during the period of totality was neither verified nor the reverse, since the unfavorable atmospheric influences appear to have cut off this part of the exhibition at those few stations from which accounts have been received here. You may imagine with what eager interest we are awaiting the arrival of more detailed accounts from Europe or the United States.

You have unquestionably heard of the fearful pestilence which has been desolating the capital of this republic. The yellow fever, which broke out there at the close of January, has made such ravages that all commerce has been suspended, banks and public offices are closed, and not less than ⅘ths of the population have fled to the suburbs. The gates of the only practicable road to the interior of the country have been closed by the absolute interdiction of travel which the municipal authorities of Rosario have succeeded in imposing, notwithstanding the fever appears to have been purely local, and there is no authentic account of the disease being communicated in a single case at the distance of five miles from the center of the city. A few fatal cases have occurred where the patient left the city after contracting the infection, but the great majority in such cases have recovered. Within the city limits of Buenos Aires, the mortality has been terrific, reaching at one time a daily average of 500 in a population reduced, by the flight of all who could escape, to a number probably not much, if at all, exceeding 50,000.—The official reports give a total of more than 15,000 deaths from yellow fever since the middle of February up to which time the fatal cases were restricted to a single ward and seldom amounted to more than eight or ten a day. At first, too, the better classes escaped, but ultimately all classes were attacked indiscriminately, and in all parts of the city. The disease is at present on the wane quite rapidly, and the telegraph officials are returning to their posts, so that we are in daily receipt of more encouraging accounts.

Among the minor evils of this fearful epidemic have been the financial irregularities from which not only all government institutions, but likewise all commercial and social relations, have suffered. Even the Observatory has not escaped its share of these, although all public officers have done their best in its behalf, and have shown a most gratifying and encouraging interest. The citizens and authorities of Cordoba, too, have shown themselves desirous of aiding us on all occasions and in every way, and the Observatory has suffered decidedly less than other public institutions in this exceptional condition of affairs.

A scientific faculty is now organizing in this ancient university; and the professors of Chemistry, Botany, and Mineralogy have arrived from Germany and are already engaged in their respective researches. The flora of this region seems to be a characteristic one, but to contain a peculiarly small number of species. The professor of botany is making extensive collections, from which our own museums will doubtless profit in good time.

Before this reaches you, I trust that not only will the observatory have been completed by the erection of the portion which left the United States in January and is probably at this very moment in the waters of the River La Plata, awaiting the reopening of the port of Buenos Aires, but also that our regular zone-work will have fairly begun. Still we have become inured to delays, and the vigorous prosecution of the Uranometry leaves no time to be consumed in lamentations.

If you know of any good man who has a few thousand dollars which he is disposed to contribute to the advancement of Astronomy, please tell him that there are few if any ways in which they could be so effectively bestowed, as in securing photographs of the Southern sky at the present time. I have with me here the object glass with which Mr. Rutherfurd took his magnificent photographs of the Moon, the Pleiades, the Præsepe and the cluster in Perseus, and am only in need of a mounting for the telescope, chemical equipments and a trained photographer, all of which a little money would enable us to secure without delay.—With these appliances, more astronomical material of the sort, to which the photographic method is specially adapted, could be collected in two years, than without it in twenty. And this material, once secured, can be elaborated at any subsequent time and the work repeated by any number of independent investigators.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the Spectrum of Uranus.*—The spectrum of Uranus was first observed by Secchi in 1869. He noticed a complete absorption of the yellow rays, while there were two large black bands, one in the green and the other in the blue. The band in the blue was less refrangible than F; that in the green was near E. Mr. Huggins has observed the spectrum of this planet with a 15-inch refractor by Messrs. Grubb & Son, and has determined the existence and position of six strong absorption bands. The positions of these bands were measured by means of the micrometer and by comparison with the spectra of terrestrial substances. The strongest of the lines has a wave length of about 0·000544^{mm}. The others corresponded respectively to wave lengths of about 0·000572^{mm}, 0·000595^{mm}, 0·000618^{mm}, 0·000486^{mm} and 0·000634^{mm}. The band at 0·000572^{mm} is nearly as broad but not as dark as that at 0·000544^{mm}. The band 0·000486^{mm} corresponds to F of the solar spectrum. The author found that the absorption bands of Uranus could not be ascribed to the presence of carbonic acid, and also that there is no strong line in the spectrum of the planet which corresponds to the strongest of the air lines, the double line of nitrogen, although the two planetary bands 0·000595^{mm} and 0·000618^{mm} very nearly coincided with bright lines of air.—*Proceedings of the Royal Society, and Nature, for June 1st*, 1871.

W. G.

2. *On the application of the Spectroscope to the measurement and comparison of the intensity of colored light, and to the quantitative determination of Coloring Matters.*—Vierordt has succeeded in applying the spectroscope to quantitative determinations of considerable interest and importance. To determine the relative intensity of the light of different portions of the spectrum, the author employs a spectroscope provided with the ordinary scale telescope. The scale itself is however removed, and a slit arrangement similar to that of the collimator substituted. This slit is illuminated by a constant source of light, which serves as the standard. The intensity of this light may be varied either by varying the width of the slit, by changing its distance from the source of light, or by the employment of smoke-tinted glasses as absorbing media. The image of the slit being reflected from the surface of emergence of the prism appears superficial upon the spectrum, and when the intensity of the white light from the constant source is sufficiently intense, the spectral color at a given point will disappear. If now the intensity of this light is diminished gradually, a point will be arrived at for which the parts of the field of view illuminated by the pure spectral colors can no longer be distinguished from the corresponding part illuminated at the same time by the spectral colors, and by the faint white light. It is to be borne in mind that if the dark lines in the spec-

trum are vertical, the white image of the slit occupies only a portion of the central line of the spectrum, so that the pure spectral colors admit of direct comparison with those which are diluted with superficial white light. The principle of measurement depends therefore upon the capacity of the eye to distinguish differences of intensity of light of different colors. For the description of the apparatus employed and the details of the method, we must refer to the original paper. The author describes, however, one part of the apparatus, which we shall here notice as a valuable addition to the spectroscope when used for other purposes. This consists of a moveable plate carrying an adjustable slit, which is introduced into the eye-piece of the observing telescope, so that the plane of the slit coincides with that of the image. The slit may be made to traverse the whole field of view, by means of a screw; in this manner the whole spectrum may be excluded from view, with the exception of a given narrow portion. This arrangement enables the observer to examine a limited part of the spectrum for a long time without fatigue to the eye, and is of special use in examining faint positive* spectral lines.

In another paper the author points out a method of applying the spectroscope to the quantitative determination of coloring matters. The moveable plate which forms one half of the slit of the collimator is divided into two portions, each of which can be moved parallel to itself by a micrometer screw with divided head. When the two slits are of exactly equal breadth, the upper and lower halves of the spectrum will have the same intensity. If one of the slits, for example the upper, has a colored glass or other absorbing medium placed in front of it, the spectrum will be divided into two halves of unequal intensity. If now the other slit be narrowed gradually by means of the screw, the intensity of the light will gradually diminish until it becomes exactly equal for the two halves of the spectrum at a given part or region of color. The equalization of the light in the two halves of the spectrum is quickly produced, and in this manner the ratio between the quantity of light transmitted through the colored plate and the original intensity of the light is easily expressed in percentages. If C represents the degree of concentration of a colored solution, E its coefficient of extinction and A the coefficient of absorption of the dissolved active substance, we have $C=AE$. Hence the degree of concentration of a solution may be found by simply measuring its coefficient of extinction, provided that the coefficient of absorption of the dissolved substance has been determined once for all. The author promises hereafter a work on the application of the spectroscope to quantitative chemical analysis.—*Die Anwendung des Spectral-Apparates für Messung und Vergleichung der Stärke des farbigen Lichtes, Tübingen*, 1871; *Berichte der Deutschen Chem. Gesellschaft, 4ter Jahrgang*, No. 6, p. 327.

W. G.

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* To avoid circumlocution, it seems desirable to employ the terms positive and negative, to denote respectively bright or dark lines or bands.—W. G.

3. *On the heat of neutralization of organic and inorganic bases soluble in water.*—J. THOMSEN in Copenhagen, has published the principal results of a recent investigation of the quantities of heat evolved in the neutralization of different bases of the same acid. These researches have led to the remarkable result that the so-called hydrates of the oxides of K, Na, L, Tl, Ba, Se, Ca and Mg evolve on saturation with sulphuric acid the same quantity of heat, the neutralization being in all cases that of one molecule of sulphuric acid. The quantity of heat evolved amounts to 31134 as a mean, the single values differing almost ½ of 1 per cent from this mean. Sulphuric acid evolves with other inorganic bases a less quantity of heat. Thus the heat of neutralization of PbO is 18750^c; that of Ag_2O 14040^c. The author infers from this result that the chemical character of the process of neutralization is different in different cases. Thus the first named eight bases do not evolve the same quantities of heat with one molecule of other acids. Thallium with chlorhydric and sulphydric acids behaves like silver, so that the numbers are nearly the same for the two metals. A solution of ammonia in water differs remarkably from the inorganic alkaline hydrates. Thus it gives with sulphuric acid only 28150^c, or 11 per cent less than the alkaline hydrates. On the other hand, tetra-methyl-ammonium-hydrate gives with one molecule of sulphuric acid 31010^c, or almost exactly the same number as the eight inorganic bases. Ethylamin gives nearly the same number as ammonia, namely, 28350^c. Triethylstibin-oxide, a divalent base, gave with sulphuric acid hardly 10 per cent of the heat of the alkaline and earthy bases, whence the author infers that it is a base of a wholly different character. From the above mentioned results, he considers it probable that an aqueous solution of ammonia does not contain a hydrate of ammonium, and that it is only an ammonium-base proper which is analogous to an alkaline hydrate. In conclusion, the author promises an investigation of the thermic relations of the organic bases. —*Berichte der Deutschen Chem. Gesellschaft, 4ter Jahrgang,* p. 308. W. G.

II. GEOLOGY AND NATURAL HISTORY.

1. *Currents of the Oceans.*—Mr. JAMES CROLL, in the Philosophical Magazine for 1870, volume xxxix, sustains the view that the currents of the oceans, including the Gulf Stream, are due to the action of the trade winds. Dr. W. B. Carpenter, in consideration of the results obtained by the deep ocean soundings has presented positive evidence that the ocean is stirred by its currents to its very bottom (this Journal, vol. xlix, p. 410, 1870), and claims, we think rightly, that the superficial action of the trades is not sufficient cause for the movement. An elaborate memoir by Dr. Carpenter "on the Gibraltar Current, the Gulf Stream and the General Oceanic Circulation," has been published during the current year by the Royal Geographical Society, from which we cite his conclusions, after stating the general principles on which he bases them.

A vertical circulation is maintained in the Strait of Gibraltar by the *excess of evaporation* in the Mediterranean over the amount of fresh water returned into its basin, which at the same time *lowers its level* and *increases its density;* so that the *surface-inflow* of *salt* water which restores its level (exceeding by the weight of salt contained in it the weight of fresh water which has passed off by evaporation) disturbs the equilibrium and produces a *deep outflow*, which in its turn lowers the level.—The same may be assumed to be the case in the Strait of Babelmandeb.

A vertical circulation is maintained in the Baltic Sound by an *excess in the influx of fresh water* into the Baltic; which at the same time *raises its level* and *diminishes its density*, so as to produce a *surface outflow*, leaving the Baltic column the lighter of the two, so that a *deep inflow* must take place to restore the equilibrium.—The same may be assumed to be the case in the Bosphorus and Dardanelles.

A vertical circulation must, on the same principles, be maintained between polar and equatorial waters by the difference of their temperatures; the level of polar water being reduced, and its density increased, by the surface-*cold* to which it is subjected, while a downward motion is also imparted to each stratum successively exposed to it; and the level of equatorial water being raised, and its density diminished, by the surface-*heat* to which it is exposed. (The first of these agencies is by far the more effective, since it extends to the *whole depth* of the water, while the second effects, in any considerable degree, only the *superficial stratum.*) Thus a movement will be imparted to the upper stratum of oceanic water from the equator toward the poles, while a movement will be imparted to the deeper stratum from the Poles toward the equator.

Of such a *vertical circulation* in the general body of oceanic water we have evidence, on the one hand, in the *northerly* movement of the upper stratum, *of several hundred fathoms' depth*, which carries the temperature of a warmer region into the Arctic circle; while, conversely, there is now a large body of evidence as to the *general prevalence*, over the deep-sea bottom, of *a temperature not many degrees above the freezing-point of fresh water*, which cannot be accounted for in any other way than by an underflow of polar water toward the equator. Further, under particular circumstances, a yet greater degree of cold is brought by glacial currents into the Temperate zone: thus giving distinct indication of a general movement of deep water from the poles toward the equator.

Lastly, it follows, if the foregoing doctrine be correct, that the general *vertical* oceanic circulation is the great agent in moderating the extreme cold of the Arctic basin; the water which flows toward it being not so much propelled into it by the Gulf Stream, as drawn into it from an area of which the ordinary temperature is little, if at all, above the normal. On the other hand, the Gulf Stream forms part of a *horizontal* or *superficial* circulation in the

North Atlantic, of which the Trade Wind constitutes the *primum mobile:* a large part of its flow returns directly backward into the equatorial current, thus completing the *shorter* circulation; whilst the portion which passes northward ultimately returns in the *superficial polar currents* with which it interdigitates—one of these currents being sufficiently powerful to maintain a distinct course back to the exit of the Gulf Stream, where its deeper portion not improbably re-enters the Gulf of Mexico as a reverse under-current through the Narrows.

The view which Dr. Carpenter advocates, that the movement of the ocean affects the whole body of water to its very bottom, is recognized by the writer in his Report on Crustacea of the Wilkes Exploring Expedition, (4to, 1618 pp., 1852, this Journ., II, xvi, 1853), and the general system in this circulation is there pointed out,—this system according with the views previously held by the distinguished meteorologist, W. C. Redfield. The conclusions are sustained by facts relating to the temperature of the ocean observed in the course of the cruise of the Exploring Expedition just mentioned, and others from various sources, presented on an isothermal chart prepared for illustrating the geographical distribution of marine life, and especially the Crustacea; and a brief statement of this system is given in his Manual of Geology, (1861). The facts from the deep ocean remove all remaining doubt with regard to the universality of the movement, and the oneness of the system. At the same time there does not appear to be any good reason for separating from the system the Gulf Stream, as done by Dr. Carpenter. Given the vertical circulation, and the north and south movement, advocated by him, and then the revolution of the globe will make it, as has been long recognized, a *westward* movement in the tropics and an *eastward* in the middle and higher temperate latitudes, such as is found in fact in all oceans. Then, secondly, whenever, in the flow of these waters, they approach the continents, where the depth diminishes, the rate of flow will be increased in proportion (approximately) to the decrease of depth; and hence comes the stream east not only of North America and there called the Gulf Stream, but of South America, and also those east of Asia and of Australia; and also that in the higher latitudes west of South America. The Gulf Stream and all these other streams, are parts of the general system, modified by proximity to the continents; the action of the trades is not in any case their origination, though it may well be their accelerator. Neither is an Indian ocean current the origin of the current in the South Atlantic up the west side of Africa, though contributing to it.

Dr. Carpenter also combats Mr. Croll's position, with regard to the "thermal work of the Gulf Stream." J. D. D.

2. *On the "Benches," or Valley Terraces, of British Columbia;* by MATT. B. BEGBIE, Chief Justice of British Columbia.—The following extracts from this paper are selected from the Proceedings of the Roy. Geogr. Soc. for Feb. 27, 1871.—It is perhaps scarcely possible for any person who has never seen Fraser River, or ob-

tained an accurate description of it, if any verbal description can be accurate, to form an idea of its banks.

The distance from Lytton to Lilloett is 43 to 45 miles, and this may seem a considerable extent of bench formation when compared with Glen Roy, which extends but 20 miles. But the bench formation in British Columbia extends the whole distance of Fraser River so soon as the delta is left, as far as I have traveled up it, i. e. full 400 miles, and then the benches are seen running on, miles ahead. Wherever the formation has a chance of showing itself from Hope upward, i. e. wherever it is not interrupted by precipices, or chasms, or denudations, there are benches more or less clear and regular. Up the Quesnelle River, and on Cottonwood, an affluent of Fraser River next above Quesnelle, and Lightning, affluent of Cottonwood, up to within 25 miles of the Bald Mountain, the backbone of the Cariboo range, I still found exactly similar benches. The formation extends all up Thompson River, far above Kamloops, along both forks, as far as I could see. There are several well defined terraces on the Okanagan; in particular on the "Rivière du Sable," halfway down the lake, mounds like truncated pyramids, or rather a pile of four or five truncated sections of pyramids. On the only portion of the Columbia River which I have traveled, viz: Fort Shepherd to Fort Colville, the formation is just as distinct and striking as on Fraser River, and I am informed and fully believe that it is quite uninterrupted down to Snake River, in lat. 46°. The largest benches, both in length and breadth, that I have seen are in the valley of the Upper Kootenay River, about long. 115° 30′ W. (Lilloett being 122° W.). At Rock Creek, and all along Kettle River, the trails run for miles and miles along just such benches, and so too all along the Similkameen River and the Nicola River, not only at its influx into the Thomson, where there are six or eight heaped one upon top of another, but all along its course to the Nicola Lake. In fact, it may be said that everywhere in the Colony on the east side of Fraser River, wherever there is a river of any size, and the hills or mountains are near, but not too near, you find yourself on one of these benches, more or less regularly formed, but even when externally irregular, bearing traces of original regularity.

The benches are to all appearance in their normal state, level in the direction of the neighboring stream. But I suspect that they follow its general inclination—it might be said, incline "conformably" with the stream, as a general rule. For instance, it is very common for ditches—which, of course, always have some fall, though their fall varies extremely from an inch in a mile to an inch or more in a yard—to be carried along a bench in the direction of the principal stream, very rarely against that direction, and only when the supply is taken from a side creek, when, of course, the ditch may be taken in any direction. This question could not be determined without levelling a good many benches carefully. I should not be disposed to place much reliance on a barometer for such minute differences of level, and any hypsometer I have seen would be useless. But as to the transverse inclination (i. e. in the direction at right angles to that inquired of by Mr. Robinson), a great many benches, especially as they recede from the river, have a very decided inclination, i. e. they slope from the mountain toward the stream, and sometimes very rapidly, as if an upheaving force had burst through a slightly flexible stratum of drift, and raised it to the highest point just before it finally emerged. Nevertheless the benches sometimes slope the reverse way; so that I know two or three instances of benches where lakes are formed next to the mountain base, the bench presenting an appearance similar to the "lip" on rivers running through alluvial flats, but which appearance is, I think, due to quite a different cause from the "lip," viz: to a local depression having taken place after the formation of the bench.

Just before reaching Lilloett, the benches become exceedingly striking. Speaking from memory, I should say there were at least five or six different benches, apparently as level, green, and well defined as billiard tables, on the east bank, and a still greater number on the west bank, or Lilloëtt side, where they are intersected in a most picturesque way by the brilliant N'Koomptch, running through the magnificent gorge leading from Seton Lake, about three miles from the Fraser, the northern extremity of the Douglass trail already referred to.

There are, I should say, speaking from memory, at and in sight of Lilloett, at least 15 or 16 benches on both sides at various levels, some three or four on each side of Fraser River exactly corresponding in level: but many on either side of the river having no apparently exact counterpart on the other bank. Lilloett stands on a plateau, which I judge to be about 160 feet above high-water mark of Fraser River, varying, between March and June, from 30 to 40 feet vertical. I have never been on the highest bench in this neighborhood, which I should say is on the east side, and which I should judge to be 500 or 600 feet above the Fraser.

There are, I should think, on the fort side (west bank of the river) at least twelve or fifteen terraces immediately at Alexandria; and from their regularity and contiguity—being generally narrow, and differing only a few feet in height—present a very singular and striking appearance: like a gigantic flight of steps ascending the hillside gradually.

The above are the more important facts presented by Mr. Begbie. From them he draws the conclusion that the "benches" or terraces are due to a vast lake, or series of lakes, and that this drainage was connected with an elevation affecting "a large mass of the continent," raising, at different periods, "various ridges of hills and mountains, either together or separately," and resulting in protruding them through the wide spread lacustrine formation.

3. *Note on River Terraces;* by J. D. Dana.—The first observations on the terraces of Oregon and California will be found in the Geological Report of the Wilkes' Exploring Expedition, by the writer, published in 1849, and in this Journal, 2nd ser., vol. vii, in which places the terraces or benches are attributed chiefly to river action. They are shown to be part of a system of terraces that

covers a large part of North America, north of the Ohio, and existing on all streams, as far as examined, nearly to their heads in the mountains, as stated above to be the fact with those along some streams on the Pacific border. It is there remarked that if admitted to be lake terraces, the facts would prove that a large part of the continent had been covered with lakes in place of rivers, and just where rivers should have existed, which is a view not to be entertained.

The lower flats or flood grounds now existing along any stream follow it to its head, with interruptions depending on the width of the valley and nature of the enclosing deposits (whether hard rock or not); and thus such flats, while the sea has its present level, may exist on a single river at all heights, from a few feet above the sea level to the height approximately of its source, or through a range of level it may be of thousands of feet. Such flood grounds are approximately parallel to the adjacent bed of the stream, the variations depending largely on obstructions in the course of the stream and being such very nearly as actually exist between flood level and low-water level.

If now a part of the continent be raised 50 feet, the abrading or excavating force of the streams would be increased; the low-water channel would be accordingly deepened by abrasion, and a new flood ground or lower flat would also be produced with the old flood ground as a terrace or bench. The height of this terrace or bench would depend on the depth of the river excavation; and this on the nature of the bottom, etc.; thus with a single elevation of 50 feet, terraces may be made at all heights above the sea from 50 feet to 5000 or more, according to the height of the head-waters of the rivers. This fact is of the highest geological importance; very many errors as to evidences of changes of level have been made from a failure to consider it. Moreover, more terrace levels than one might be formed on this single sudden rise of the land wherever there were obstructions that were afterward successively removed. Such obstructions might in some parts of a stream make lakes, and cause true horizontal benches for an interval. Thus the terraces or benches along streams may be accounted for without recourse to lakes except those that would be incidental to such a system of river changes. They are evidences that the stream has excavated its bed to a lower level than that which it formerly had; and the proof as to change of level indicated is to be derived not from an isolated fact in any place, but from a general survey of all the facts throughout a great region—facts as to heights of terraces, as to excavating force of stream in its different parts, and as to possible obstructions that have put a limit to excavation or occasioned intervals of retardation.

4. *Glaciers.*—The Philosophical Magazine for June, (pp. 485–508) contains a translation of a valuable paper on Glaciers from Poggendorff's Annalen, by ALBERT HEIM of Zurich. The following paragraphs are from pages 495, 496.

M. Grad ascribes to the freezing of the infiltrated water in the capillary fissures, not only the enlargement, but also the "crystallographic orientation" of glacier-ice, discovered by Bertin, and afterwards confirmed and generalized by MM. Grad and Dupré. But he seems to me to form no accurate conception of how this is to be produced by the water freezing round the surface of the grains. It might be very difficult to do so. I am inclined rather to look upon the "crystallographic orientation" as a function of the pressure. The ice masses of the lower part of the glacier, in which it has been observed, are not the same which in the upper part did not exhibit the phenomenon; they are those which, during many years, have sustained the mighty pressure of the overlying layers of ice, now melted away. When we consider that, in a body the temperature of which is always near its melting-point, molecular derangements readily take place, and that there is no lack of shocks which go through the mass of ice (such as occurs, for example, in the crash whenever a crevasse opens or closes), the latter notion becomes still more probable. The phenomenon observed by MM. Bertin, Grad, and Dupré, that in lamellæ cut horizontally out of the lower part of the glacier colored rings with a black cross are seen when they are viewed in the polarizing microscope, does not necessarily indicate actual crystalline structure; amorphous glass can yield the same phenomenon through strains forced upon it by external pressure. It appears to me that the effect in the glass also would necessarily be permanent, if the violent pressure had operated for many years. Experiments on a small scale, for the purpose of producing by pressure the crystallographic orientation in pieces of ice, gave no result. This is not surprising; for I could not, as many a glacier does, operate with a pressure of 5 cwt. per square inch, or factors of similar magnitude. Already in the 27th volume of the Philosophical Magazine Sir John Herschel conjectured a parallel arrangement of the optic axes, but not on grounds corresponding with M. Grad's explanation.

I must not, however, omit to mention that, according to the calculations of an Englishman (Canon Moseley) in the Philosophical Magazine for May, 1869, the resistance of the ice to the shearing-forces of the glacier-motion would be too great for the ice to be broken by gravity alone and thus the glacier to move by its own weight. If I rightly understand the experiments of Tyndall and my own on the remoulding of plates of ice, the ice therein and in the glacier is not compelled to shear, but to break by the bending. The shearing, tangential displacements take place along the fissures previously produced by fracture (bending). The very peculiar mechanical conditions of the ice seem to me not to have been sufficiently considered in the calculation. One of these is its extraordinary brittleness even at 0° C.; the same pressure which a mass of ice will sustain in a state of rest for a long time without breaking, breaks it immediately if a shock is added. Another is the occurrence of crowds of minute air-bubbles, which must very much diminish the compactness of the ice. In the lower part of a glacier, where air-bubbles are almost absent, we have the old, only half regelated secondary capillary fissures, along which fresh fracture is easier: while in this region the primary fissures are somewhat less numerous, the secondary (which are longer preserved) exhibit a peculiar abundance of plaits. So many factors, unmeasured in their effect and scarcely known in their mode of operation, are involved in the mechanics of glacier-motion, that the result of a calculation based on the little that is known cannot possibly induce me antecedently to reject the explanation by pressure, with which all the facts of which I have any knowledge, and all that I have seen, agree so perfectly. According to the explanation of glacier-motion given by Mr. Moseley (Phil. Mag., Jan. 1863 and Aug. 1869), the total motion must be, on the average, equal in amount in the upper, middle, and lower parts of the glacier, which is not the case. As in no part of the glacier, certainly not at the lower end, has any (even the least) upward motion ever been observed at certain times, the line which, as a base, remains relatively fixed must, when the temperature falls, lie at the upper end of the glacier; when the temperature rises, at the lowest point. That with rise of temperature the lower end would remain stationary, and drag after it the whole long glacier-tongue (which cannot descend by its own weight), without its being rent transversely into single independent fragments, I cannot conceive. The surface of the glacier undergoes more and greater variations of temperature near its margins than in the center—now from reflection of heat from the sides of the valley, then from their shade, but especially through the winds (which in the center arrive with their temperature already approximated to that of the glacier). The margins have in some measure a more continental, the center a more oceanic climate. Hence one would think that the edges of the glacier would move faster than, or at least as fast as the center, if variations of temperature effected the motion.

I have not the remotest intention to summarily reject Mr. Moseley's views; but I thought it admissible to state what at present appears to me opposed to them, in order to justify my continuing to hold Professor Tyndall's explanation. Perhaps Mr. Moseley will be able to remove these difficulties and, especially by measurements of the interior temperature of glaciers, give his views a better foundation.

5. *On Sigillaria, Calamites and Calamodendron.*—Dr. J. W. Dawson, in the Q. J. Geol. Soc. for May, 1871, discusses the nature of these fossil plants and presents many facts of his observation. The tissues of the Sigillariæ, and the character of the fruits (*Trigonocarpum* and *Cardiocarpum*) which very often accompany the trees, are regarded as proving that they are true Gymnosperms or are related to the Conifers and Cycads. But he further remarks that possibly the group may have included forms bridging over the interval between the higher Acrogens (the Calamites on one side and the Lepidodendron on the other) and

the Gymnosperms. The *Calamites*, according to Dr. Dawson, are true Equisetaceous plants, and the fossils exhibit the exterior surface of the stems. But other fossils marked externally like Calamites are casts of the pith or *internal axis*, and belong to the genus *Calamodendron*. The Calamodendra often have a considerable thickness of woody envelop about the apparently jointed internal axis, consisting of woody tissue in wedges separated by intervening tracts of cellular tissue (medullary rays according to Williamson); and they are therefore classed by Dr. Dawson with Gymnosperms.

Dr. Dawson makes the line from Sigillaria to Lepidodendron to include, in order, *Lepidophloios*, *Syringodendron*, *Clathraria*, *Favularia?*, *Rhytidolepis;* and the line from *Sigillaria* to *Equisetum* to include *Calamodendron Calamopitus* (of Williamson), *Bornia*, *Calamites.*

6. *Lepidodendra and Sigillariæ.*—In a paper read before the Royal Society, June 15, Prof. W. C. Williamson describes the structure of specimens of *Lepidodendra selaginoides*, and appears to make good the conclusion that it has an imperfect exogenous structure. He observes that it has a central medullary axis, which is closely surrounded by a second and narrower ring also of barred vessels, but of smaller size, and arranged in vertical radiating laminæ "which are separated by short vertical piles of cells believed to be medullary rays. In a transverse section the intersected mouths of the vessels form radiating lines," and the structure is pronounced an early type of an exogenous cylinder. From this cylinder alone the vascular bundles going to the leaves are given off.

He describes *Stigmaria* ("well-known," he says, "to be a root of Sigillaria,") as having "a cellular pith without any trace of a distinct outer zone of medullary vessels such as is universal amongst the *Lepidodendra*. The pith is immediately surrounded by a thick and well-developed ligneous cylinder, which contains two distinct sets of primary and secondary medullary rays." Other facts stated tend to show that these plants are of the Lepidodendroid type, and Prof. Williamson therefore includes the *Lepidodendroid* and *Sigillarian* plants in a common family, making them, along with the *Calamiteæ*, to constitute an *Exogenous* division of the vascular Cryptogams, while the *Ferns* belong to an *Endogenous* division, "the former uniting the Cryptogams with the Exogens, through the Cycadeæ and other Gymnosperms; and the latter linking them with the Endogens through the Palmaceæ.

7. *Helderberg Corals in New Hampshire.*—Prof. C. H. Hitchcock, State Geologist of New Hampshire, announces the discovery of Helderberg corals in Littleton, N. H. New Hampshire has been considered an Azoic State by some, as its rocks are mostly of a granitic character. Professors H. D. and W. B. Rogers supposed at one time they had found Silurian fossils in the White Mountain Notch, but afterward withdrew the opinion.

The limestone containing these corals has been traced for about three miles, and appears to be duplicated by a synclinal fold. It overlies the metamorphic Quebec group on one side, and probably the Coös group on the other. It appears to be overlaid by a clay slate carrying a few worm-trails.

The corals themselves are obscure. They have been submitted to the examination of E. Billings, F.G.S., of Montreal. He recognizes the *Favosites basaltica*, and a *Zaphrentis*. The rock appears to be identical with that cropping out upon lake Memphremagog and its supposed continuation into Vermont. The New Hampshire locality is fifty-five miles southeasterly from the Canadian. As the associated rocks are somewhat similar, it is likely that the two limestones are of the same age. Mr. Billings does not speak positively of the distinctive age of the Canadian limestone. It seems to range from the Lower to the Upper Helderberg. He compares it with the Gaspé limestone, which corresponds with the entire Helderberg series of New York. A fossil from Owl's Head, shown to Professor Hall by the writer several years since, was declared to be the peculiar *Atrypa reticularis* of the Upper Helderberg. With our present information it is only possible to say that Helderberg fossils have been found in New Hampshire. C. H. H.

8. *On Fossil Coal plants from the Altai;* by Dr. H. B. Geinitz. (From Cotta's "Der Altai," in course of publication).—The coal plants here noticed were brought by Dr. Cotta from the Museum of Barnaoul. They are mostly of described species already recognized there by Eichwald and others. The species remarked upon are *Equisitites Socolowski* Eichwald, *Anarthrocanna deliquescens* Göpp., *Cyatheites Miltoni* Artis, *Annularia longifolia* Brgt., *Cyclopteris orbicularis* Brgt., *Sphenopteris anthriscifolia* Göpp., *Lepidodendron Serlii* Brgt.; a *Pterophyllum* near *Pt. inflexum* Eichw. (on same specimen with *Annularia longifolia*); *Trigonocarpus acteonelloides* Gein., *Nœggerathia œqualis* Göpp., *N. palmœformis* Göpp.; *N. distans* Göpp.; *Araucarites Tchithatcheffianus* Göpp.—Geinitz mentions the fact of the occurrence of a Cycad, *Pterophyllum blechnoides* of Sandberger, in the Carboniferous beds of the Baden Schwarzwald, to show that the Siberian species is not a solitary case. The memoir is illustrated by three lithographic plates. Dr. Geinitz remarks in closing that the species are not Permian, and that they belong to the later Carboniferous.

9. *Preliminary Report on the Vertebrata discovered in the Port Kennedy Bone Cave;* by Prof. E. D. Cope, (Proc. Am. Phil. Soc., April 7, 1871).—This paper, mention of which is made in vol. i, on page 384, of this Journal, (May, 1871), contains descriptions of 5 species of Megalonyx, *M. loxodon*, *M. Wheatleyi*, *M. dissimilis* Leidy, *M. sphenodon*, *M. tortulus*, *Mylodon? Harlani*, *Sciurus calycinus* Cope, *Jaculus? Hudsonius* Zimm., *Hesperomys* ——?, *Arvicola speothen* Cope, *A. tetradelta* id., *A. didelta* id., *A. involuta* id., *A. sigmodus* id ; *A. hiatidens* id.; *Erethizon cloacinum*

id.; *Lepus sylvaticus* Bachm.; *Praotherium* (a genus near *Lepus*, Cope) *palatinum; Scalops* ——?; *? Vespertilio* ——; *Mastodon Americanus; Tapirus Americanus; T. Haysii* Leidy; *Equus* ——?; *Bos* ——?; *Ursus pristinus* Leidy; *Felis* ——? In all there are 34 species, and 72 individuals. Of them, 11 are American tropical forms, 3 North American Arctic, 11 are common to both hemispheres; and 9 are of uncertain regional relations. Prof. Cope concludes with a discussion of the relation of the species to the earlier American fauna, the geographical and other changes of the Post-tertiary, and the origin of the cave.

10. *Winkworthite;* Prof. How.—Winkworthite is a borate occurring in nodules in the gypsum quarry at Winkworth, Hants Co., Nova Scotia. It forms nodules, as large as a walnut. A surface of fracture was flat, and was covered with glistening irregular facets, and scrapings showed under the microscope transparent oblique-angled plates. H. = 3, but of outside 2. In the closed tube yields water and becomes opaque. B.B. decrepitates and fuses easily to a clear bead, giving a bright green flame; in continued blowing, froths, the bead becomes opaque and the flame loses its green color. Analysis afforded Sulphuric acid 36·10, silica 3·31, boracic acid by loss 10·13, lime 31·66, water 18·80, which composition affords the atomic proportions $9\dddot{S}$, $\dddot{Si}$, $3\dddot{\bar{B}}$. $11\dot{Ca}$, $20\dot{\bar{H}}$.

Another nodule afforded $\dddot{S}$ 31·51. $\dddot{Si}$ 4·98, $\dddot{\bar{B}}$ by loss, 14·37, $\dot{Ca}$ 31·14, $\dot{\bar{H}}$ 18·00, whence the ratio, $8\dddot{S}$, $\dddot{Si}$, $4\dddot{\bar{B}}$. $11\dot{Ca}$, $20\dot{\bar{H}}$.

Ulexite has been found in Nova Scotia, in gypsum, at Clifton Quarry, Windsor; Brookville; Trecothick's Quarry; Three Mile Plains; Winkworth; Newport Station. *Cryptomorphite*, in Glauber salt in gypsum at Clinton Quarry. *Howlite*, in gypsum and anhydrite at Brookville, and in gypsum at Winkworth, Newport Station, and Noel.—*Phil. Mag.*, April, 1871.

11. *Trinkerite.*—A fossil resin, described by TSCHERMAK, containing over 4 p. c. of sulphur, from an Eocene coal bed, at Carpano in Istria. This sulphur-bearing resin has been observed also, by T. Niedzwiedski, at Gams, near Hieflau in Styria, imbedded in a dark colored rock of the Upper Cretaceous formation.—*Bulletin of the K. Akad. Wien. Nature*, No. 87.

12. *Arrangement for Cross fertilization of the flowers of Scrophularia nodosa.*—It is probable that the dichogamy of the flowers of *Scrophularia* has already been observed and published; but it was new to me until pointed out this season by my assistant, Dr. Farlow. The arrangement is thus: In the freshly opened blossom the upper part of the style is bent forward so as to bring the stigma now ready for pollen, just over the patent lower lip of the corolla: the anthers, not yet dehiscent, are out of sight toward the bottom of the corolla, the filaments being strongly recurved or doubled over. In the blossom a day or two older, the stigma has dried up, the style become flabby; and the filaments have straightened so as to bring the four anthers up to the gorge of the corolla at the base of the lower lip, just back of the now withering stigma; the transversely dehiscent anthers are now widely open. The

flowers are visited by honey-bees, which barely insert their heads into the gorge of the flowers; the chin or throat of the bee, coming into contact with the lower lip of the corolla, is necessarily dusted with pollen from the older flowers; and this pollen, in the passage from flower to flower, and plant to plant, is inevitably applied to the stigma of the freshly opened flowers, which alone is in condition to receive it. The nectar sought by insects is here secreted abundantly by the corolla, at its base on the posterior side, and to some extent by the disk which girts the base of the ovary; the posterior face of the scale which represents the anther of the fifth stamen is apparently glandular, but hardly if at all nectariferous. Bees plunge their proboscis to the bottom of the flower. A. G.

13. *Transmutation of Form in certain Protozoa.*—Mr. **Metcalfe Johnson** has a paper on this subject, in the number for May, (No. 29), of the Monthly Microscopical Journal, (London), presenting views similar in some respects to those of Mr. Hilgard, (pages 20 and 88, of this volume). The following passages from the article present the general conclusion of the author.

In the 'Monthly Microscopical Journal' for April, 1870, I have ventured to remark that "Monas and its congeners become at once important as agents in removing dead cells, and in their place supplying us with *green* verdure which is springing up around us on every side." Everyone must have observed that universal greenness which, after the lapse of a few weeks, spreads more or less over every weather-exposed surface, large or small. Sir Humphrey Davy, writing forty years ago, says, "A polished surface of a building or a statue is no sooner rough than the seeds of lichens and mosses which are constantly floating in the atmosphere make it a place of repose, grow and increase." If we examine a few of the green growths upon these surfaces differing from one another in their surroundings, or "choses extérieures," such as moisture, light, temperature, &c., we shall find one composed of a green dust, to which the name of *Chlorococcus* has been applied; another, a green scum upon the surface of a liquid, which has received the name of *Euglena;* a third, forming patches of dark green slime upon old walls, and called *Oscillatoria;* a fourth, *Lyngbya;* a fifth, *Vaucheria;* a sixth, *Schidzonema*, and so on. A more detailed examination of these separately-named products, and a study of their life-history, leads to the opinion that they are all (more or less) stages of development of some one common source, which it is the object of the present remarks to identify as the monad, or pin-point, source of life, which has been pointed out by Dr. Bastian and others as the earliest form in which we recognize living matter.

In order to commence this investigation I will append a few observations I have made on various forms of *Paramæcium*, and I shall endeavor to show that it constantly transforms to *Vorticella*, and thence passes to *Callidina elegans*, thus tracing one of the phases of growth by development from the simple form of *Monas* to some of the more complicated animalculæ or Entomostraca. I shall hope in a future communication not only to trace the *Paramœcium* from the monad, but also to show that the "choses extérieures" being altered the monad may become a *Chlorococcus*, an *Oscillatoria*, a *Lyngbya*, a moss, a lichen, an *Amœba*, or a *Mucedo.*

14. *Embryological Studies on Diplax, Perithemis, and the Thysanurous genus Isostoma;* by A. S. PACKARD, Jr. Memoirs of the Peabody Academy of Science, Volume I, Number 2. Salem, Mass., March, 1871.—This memoir contains quite full and interesting descriptions of the development of the embryos of *Diplax* and *Isostoma*, with a few observations on *Perithemis.* "An interesting point in the embryology of *Isostoma* is the homology of the spring. Though its earliest development was not observed, it is evidently homologous with the third pair of blades comprising the unjointed ovipositor of the higher insects, and seems to be homologous with the legs and cephalic appendages." Dr. Packard also suggests that the three pairs of processes ordinarily forming the ovipositor of insects are homologous with the abdominal legs of myriapods and the spinnerets of spiders. He also concludes that the eyes and ocelli of insects do not represent limbs and that they arise on segments bearing other appendages, and, therefore, the head of insects may be considered as composed of but four segments. This memoir is illustrated by two plates and several wood-cuts. V.

15. *Seaside Studies in Natural History;* by ELIZABETH C. AGASSIZ and ALEXANDER AGASSIZ. Second edition, 1871. (James R. Osgood & Co., Boston).—This is one of the few books on Natural History which combine scientific accuracy with a popular treatment of the subject. It is, moreover, the only popular work in which many of the most interesting marine animals of our shores are described and figured. It is, therefore, gratifying to see that the work has been so well appreciated as to require a second edition. In this edition but few changes have been introduced. These are chiefly in the chapter on the distribution of marine life. A list of the wood-cuts and an explanation of the abbreviations of authors' names have been added. V.

16. *Report on the Brachiopoda obtained by the U. S. Coast Survey Expedition, in charge of L. F. De Pourtales, with a Revision of the Craniidæ and Discinidæ;* by W. H. DALL.—Bulletin of the Museum of Comparative Zoology, Vol. iii, No. 1, Cambridge, Mass.—In this paper all the species dredged by Mr. Pourtales are fully described, and the synonymy of these and other species and genera is well worked out. The anatomy of several of the species is described at considerable length. Two lithographic plates, chiefly anatomical, illustrate this paper. V.

17. *Arrangement of the Families of Mollusks;* by THEODORE GILL. Smithsonian Miscellaneous Collections, February, 1871.—In view of the wide diversity of opinion among zoölogists concerning the classification of Mollusca, it is not to be expected that any scheme that can be proposed at present will be generally adopted. Yet we are constantly approximating to a true natural classification of these animals, thanks to the numerous anatomical investigations that have recently been undertaken. The author of the

present work fully acknowledges the provisional character of the arrangement which he has adopted, and anticipates many changes hereafter. In reality, some improvements made within the past year would doubtless have been adopted, had not the work been in type some six months before its actual publication. It is, nevertheless, the best index to the classification of the Mollusca that has been published hitherto. It gives in a very convenient form an arrangement in accordance with the views of many of the most reliable malacologists. It is probable that in numerous cases too many families have been admitted, or divisions of minor value have been allowed family rank. This appears to be especially true for the Nudibranchs, where the classification of Dr. Gray has been followed. But such imperfections are of comparatively small importance in view of the uses for which this "arrangement" is intended. It is accompanied by a useful list of authors and an alphabetical index to the names of the classes, orders, and families. Mr. Gill admits 27 orders and 356 families. V.

18. *Supplement to the Synopsis of the Extinct Batrachia and Reptilia of North America;* by E. D. Cope (Proc. Am. Phil. Soc., March 3, 1871.)—This paper contains notices of *Sauropleura remex* Cope, *Oestocephalus amphiuminus* id., *Colosteus scutellatus* Newb. (Proc. Ac. N. Sc. Philad., 1856); *Liodon sectorius* Cope (a Mosasauroid from the N. Jersey Cretaceous); *Zygorapha microglypha* id., (of the family Adocidæ) from the New Jersey Cretaceous; *Catapleura ponderosa* Cope, Cretaceous of N. Jersey; the Crocodilian, *Bottosaurus macrorhynchus* Harlan, from the upper bed of Cretaceous Green Sand of New Jersey (the *Croc. basitruncatus* Owen, in Cope's Syn., p. 65, a species of *Holops*, on p. 231); the Dinosaur, *Hadrosaurus cavatus* Cope, from same locality, a species of gigantic size.

19. *Animals of Sponges.*—Mr. H. J. Carter, whose researches on Sponges, confirming the observations of Prof. H. James-Clark, are briefly noticed on page 70, has an extended article on the subject in the Annals and Magazine of Natural History, for July, 1871 (IV, viii, 1), illustrated by two plates.

20. *On the Homologies of some of the Cranial bones of the Reptilia, and on the systematic arrangement of the class;* by E. D. Cope. (Proc. Amer. Acad., xix, 194–247.)

III. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Note to the Article on a new attachment to the Lantern, on page* 71. From a letter to the Editors dated, Hoboken, N. J., July 8, 1871.—I have just noticed the description of my vertical lantern which you have been kind enough to publish in your July issue, and find that through some inadvertence, a credit has been omitted which I have been careful to give on all occasions.

To Prof. J. P. Cooke of Cambridge belongs the credit of first constructing a lantern to exhibit horizontal objects by first reflecting the light from the condensers upward by a mirror and then again turning the rays to the screen by a silver speculum.

Prof. Cooke kindly showed me this apparatus in operation last summer, and in the instrument which you have described I have simply improved upon his plan with reference to the mechanical arrangement, and, by interposing the first mirror between the elements of the condenser by which I have secured an evenly illuminated and uncolored field of light upon the screen, and by finding that an ordinary glass mirror silvered on the rear surface would answer perfectly well for the final reflection.

To Prof. Cooke is likewise due the idea of thus showing the waves in a tank of water circular or elliptical.

To the experiments already mentioned I have lately added a new one of unusual beauty. By clamping a large square glass Chladni plate so that one corner covers the lantern field, and covering this corner $\frac{1}{8}$ inch deep with water retained by a light ring of rubber, the most beautiful patterns of crispations changing with the change of tone given by the plate can be shown on the screen.

Yours, &c. HENRY MORTON.

2. *Note to the Article on the application of Photography to the determination of Astronomical data;* by ASAPH HALL.—Mr. David Trowbridge of Waterburgh, New York, has called my attention to the fact that Professor Bartlett of West Point, had applied the photographic method to determine the times of contact in a solar eclipse as early as 1854. Professor Bartlett's observations were published in Gould's Astronomical Journal, vol. iv, p. 33.

A. H.

3. *On the Color of Fluorescent Solutions;* by HENRY MORTON, Ph.D.—We have from Dr. Morton a paper for the next number of this Journal describing experiments of his which sustain the interesting conclusion that "all the familiar fluorescent solutions, such as the tincture of Turmeric, of Agaric, of Chlorophyl, and the solution of Nitrate of Uranium, emit lights of the same color of fluorescence—namely, blue, identical with that developed by acid salts of quinine.

4. *Indianapolis Meeting of the American Association for the Advancement of Science, Aug.* 16, 1871.—According to a circular issued by the Local Committee, the first session will be held at the Academy of Music at 10 o'clock A. M., when a reception will be extended to them by his Excellency, Conrad Baker, Governor of Indiana.

Members, and those who wish to become members, are requested, immediately upon their arrival, to register their names at the office of the Local Committee, at the State House, where they will be furnished with member's tickets, and such information as may be desired in regard to accommodations, etc. The citizens have signified their desire to extend hospitality to the members. There are likewise ample hotel accommodations, and special arrangements will be made with hotel and boarding house proprietors for reduced rates. It is therefore particularly requested that persons intending to be present, will notify the Local Secretary (Prof. E. T. Cox) by letter, as early as practicable, and when possible, state the day they will arrive.

Jahresbericht über die Fortschritte der Chemie, etc. Unter Mitwirkung von A. Laubenheimer, Al Naumann, F. Nies, F. Rose, herausgegeben von Adolph Strecker. Für 1869. Erstes Heft. Giessen, 1871.

THE

AMERICAN

JOURNAL OF SCIENCE AND ARTS.

[THIRD SERIES.]

ART. XXI.—*On the Testimony of the Spectroscope to the truth of the Nebular Hypothesis;* by Professor DANIEL KIRKWOOD, of Bloomington, Indiana.

IN March, 1846, the partial resolution of the great nebula in Orion was announced by Lord Rosse. In September of the following year, the late Prof. W. C. Bond, of Harvard University, stated, in confirmation of this interesting discovery, that the part of the nebula about the Trapezium "was resolved into bright points of light" by the great refractor of Cambridge. "It should be borne in mind," continued Prof. B., "that this nebula and that of Andromeda have been the last stronghold of the nebular theory; that is, the idea, first thrown out by the elder Herschel, of masses of nebulous matter in process of condensation into systems."

These grand achievements were regarded by the majority of astronomers as fatal to the claims of the nebular hypothesis. It is not to be denied, however, that this celebrated theory has more than recovered from the shock which it then received; that it has, in fact, been materially strengthened by the researches and discoveries of the last twenty years. The truth of this remark is strikingly exemplified by the revelations of the spectroscope. The man who at the middle of the nineteenth century would have been bold enough to predict the discovery of the physical constitution of the heavenly bodies, or the determination of the elements of which they are composed, would have been generally deemed a scientific enthusiast. This, however, and more than this, has been actually accomplished. In the hands of Huggins, Secchi, Young, and others, the *spectroscope*, that marvel of modern science, has yielded satisfactory testimony not only in regard to such stars as are reached by our unassisted vision, but even respecting the telescopic nebulæ, apparently on the outskirts of the visible creation. A detailed account of these wonderful achievements would not comport with our present purpose. Such *results*, however, as bear directly upon the theory of Laplace will be briefly noted.

1. The ring nebula in *Lyra*, the Dumb-bell nebula, the great nebula in *Orion*, and others which might be named, are not, as was but recently believed, extremely remote sidereal clusters; but *their light undoubtedly emanates from matter in a gaseous form.*

2. "According to Lord Rosse and Professor Bond the brighter parts near the trapezium [in the nebula of Orion] consist of clustering stars. If this be the true appearance of the nebula under great telescopic power, then these discrete points of light must indicate separate and probably denser portions of the gas, and that the whole nebula is to be regarded rather as a system of gaseous bodies than as an unbroken vaporous mass."*

3. Progressive changes in the physical condition of certain nebula are clearly indicated by the fact that nuclei have been established which, as shown by their spectra, are not wholly gaseous, but have passed, at least partially, to the solid or liquid form.

4. The spectroscopic analysis of the light of several comets reveals a constitution similar to that of the gaseous nebulæ.

The spectroscope, then, has *demonstrated* the present existence of immense nebulous masses, such as that from which Laplace supposed the solar system to have been derived. It has shown, moreover, a progressive change in their physical structure, in accordance with the views of the same astronomer. In short, the evidence afforded by spectrum analysis in favor of the nebular hypothesis is cumulative, and of itself sufficient to give this celebrated theory a high degree of probability.

ART. XXII.—*Experiments on the time required to communicat impressions to the Sensorium, and the reverse;* by T. C. MENDENHALL, Columbus, Ohio.

I PROPOSE in this paper to give a few of the results of som experiments, carried on during the last fall and winter, havin in view the determination of the time occupied in the perceptio of an object and the response to that perception, by an actio performed in the simplest possible manner; also, to estimate th time occupied in some cases in which the action follows the choice of one of two things, or after what might be termed a judgment of the simplest nature. An attempt is also made to determine the relative rapidity with which responses are made to impressions made upon the different senses. My method of proceeding is, briefly, as follows: Time is measured by means of an ordinary register similar to an ordinary form of the astronomical chronograph, in which I have been able to move a slip of paper with great regularity at the rate of about one and a half inches per second, the seconds being registered upon this slip by a second's pendulum according to the electric method. The person on whom the experiment is being made is seated at a table, having his hand on a key; by pressing this with his finger the circuit is completed and the time of this action registered upon the moving band of paper. I made an apparatus by means of which the circuit is completed for an instant, the moment that there appears at a circular opening about three fourths of an inch in diameter a card, red or white as I choose, which completely fills the opening. The subject is instructed to watch this opening, and to close the circuit, by pressing for a moment upon the key, immediately upon seeing the card. The actual appearance of the card and his closing the circuit in response are registered upon the band of paper by two dots, separated by an interval approximating perhaps to one-fifth of an inch. Now by carefully measuring this interval and comparing it with the registered second, I obtain, of course, an expression for the time occupied by the somewhat complex operation of his perceiving the object and acting in response to that perception. I introduce the exercise of judgment by giving him two keys, one for the right and one for the left hand, and instructing that when a white card appears he is to close with his right hand, and when a red card appears he is to close with his left hand. Of course a considerably longer time intervenes between the appearance of the card and his response in this case than in the former, and I have endeavored to express the actual time consumed in making a decision as to the color of the card by subtracting the former result from the latter; since in each case there is the same perception of the card and the same muscular action in response.

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* Monthly Notices of the R. A. S., vol. xxv, p. 156.

I have also placed on white cards two figures, differing in form as much as possible, as a circle and a triangle, operating with them in the same manner as in case of two colors. To obtain accurately the time intervening between the appearance of an object and a simple muscular response, I did not depend upon the experiment with the card, which might involve some sources of error (which if they exist, however, are destroyed by cancellation in the determinations concerning the exercise of judgment), but I also made a series of experiments in the dark An electric spark, produced simultaneously with the closing of the circuit, was observed and a response made to its appearance by pressing the finger upon the key. According to the same general plan, with appropriate apparatus I made trials concerning the sense of hearing. I arranged that by pressing upon a key, unseen by the subject upon whom I was experimenting, I could at the same time close the circuit and produce a clear and distinct sound, upon hearing which he made a response, the interval of time being measured as before. I connected my apparatus with the key-board of a piano-forte in such a way that I was able to introduce an exercise of judgment in the comparison of two tones, differing in pitch much or little as I chose. As will be seen in the results, by comparing C with E and also C with its octave, it appears, as musicians generally affirm, that it is most difficult to distinguish a tone from its octave. To study in the same way the sense of feeling, I arranged an apparatus in such a manner that I could hold it in my hand and close the circuit by striking my subject a smart blow upon the head, face or hand, as I might desire. The part of the instrument which came in contact with the skin consisted of a piece of rough, coarse sand-paper about three fourths of an inch square, so that the effect might be as immediate and prompt as possible. In every case two series of experiments were made, one by making the blow upon the back of the hand and another by making it fall about the center of the forehead. Of course the person upon whom I was operating was prevented from seeing or being able in any manner to anticipate the blow. In all of the cases except a single one the result was, as in the example following, that it required less time to respond when the blow was received upon the forehead than when it was received upon the hand. This difference may, partially, represent the time required for transmission of a sensation from the hand to the brain. In the single exception referred to, the anomaly was undoubtedly in part due to a fact afterward communicated to me by the subject himself. He informed me that the back of his hand had acquired by "cultivation" a sensibility greater than usual; that in his occupation—that of a chemist—he continually used it as a means of testing the fineness of powders With different persons as many as two thousand individual trials have been made and the errors of experiment eliminated as far as possible, by the method of averages. I give below table of the reduced results in one case, in which each numb is the mean of the results of from forty to eighty trials. A was anticipated, different individuals furnished in some cas strikingly different results, but with the one exception giv above, they all followed, I believe, the order of the following

Case of A. G. F.	Time in seconds.
Response to appearance of a white card,	·292
“ “ “ electric spark,	·203
“ “ a sound,	·138
“ “ “ touch upon the forehead,	·107
“ “ “ “ “ “ hand,	·117
“ when required to decide between white and red,	·443
“ “ “ “ “ “ circle and triangle,	·494
“ “ “ “ “ “ tones C and E,	·335
“ “ “ “ “ “ “ C and C above,	·428

Experiments of a similar nature to those which I have here recorded have been made by several European experimentalists, but none, I believe, in exactly the same manner; and as the subject seems worthy of attention I hope to pursue it further.

Columbus, Ohio, May, 1871.

Art. XXIII.—*On the amount of Time necessary for Vision;* by Ogden N. Rood, Prof. of Physics in Columbia College.

In the celebrated experiment of Wheatstone on the duration of the discharge of a Leyden jar, the conclusion was drawn that distinct vision is possible in less than one millionth of a second. The incorrectness of the data on which this conclusion rested was afterward pointed out in an admirable investigation by Feddersen, who remarks on this point: “One cannot hereafter assume, in optical and physiological experiments, that the discharge of a Leyden jar is an instantaneous act; but at the same time, by the determination of the greatest suitable resistance, it will be possible to limit the discharge to its least possible duration.”* The smallest measured duration obtained by Feddersen was one-millionth of a second.

In an article in the present number of this Journal I show how, by the use of a much smaller electrical surface, I obtained and measured sparks the duration of whose main constituent was only forty billionths of a second. With their light, distinct vision is possible; thus, for example, the letters on a printed page are plainly to be seen; also, if a polariscope be used, the cross and rings around the axes of crystals can be observed with all their peculiarities, and errors in the azimuth of the analyzing prism noticed. There seems also to be evidence that this minute interval of time is sufficient for the production of various subjective optical phenomena: for example, for the recognition of Loewe's rings (using cobalt glass); also the radiating structure of the crystalline lens can be detected when the light is suitably presented to the eye.

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* Pogg. Annalen, Band cxiii, p. 453.

Hence it is plain that forty billionths of a second is quite sufficient for the production on the retina of a strong and distinct impression; and as the obliteration of the micrometric lines in the experiment referred to, could only take place from the circumstance that the retina retains and combines a whole series of impressions, whose *joint duration* is forty billionths of a second, it follows that a much smaller interval of time will suffice for vision. If we limit the number of views of the lines presented to the eye in a single case to ten, it would result that four billionths of a second is sufficient for human vision, though the probability is that a far shorter time would answer as well, or nearly as well. All of which is not so wonderful, if we accept the doctrines of the Undulatory Theory of light; for according to it, in four billionths of a second, nearly two and a half millions of the mean undulations of light reach and act on the eye.

New York, June 30th, 1871.

ART. XXIV.—*On the nature and duration of the discharge of a Leyden Jar connected with an Induction Coil;* by OGDEN N. ROOD, Prof. of Physics in Columbia College.

PART SECOND.

IN the first part of this paper* I described certain results obtained with a Leyden jar of moderate size connected with an induction coil; measurements of the total duration of its discharge were given, and it was shown that the luminous effects were mainly concentrated in the *first act*, which was found so short as to be quite immeasurable with the means then at my disposal. As one main object in these experiments was the production of an illumination as nearly instantaneous as possible—the intention being to employ it hereafter in a totally different investigation—it occurred to me that the desired end might be still more perfectly attained by the use of a quite small electrical surface. In the set of experiments above mentioned, the coating of the jar was 114·4 square inches, so this was now replaced by a jar with a coating of only eleven square inches. The sparks it furnished, when connected with the same induction coil, were perfectly satisfactory as regards illuminating power; and I at once proceeded to measure their duration employing the means and apparatus already described. For the mirror I used silvered glass, the polished *silver* side reflecting the light; its size was half an inch square. The rod figured at W was removed, with of course great advantage to the ve locity; and as several discharges occurred in a second, it was seldom that the weight ran down without at least one good observation being obtained.

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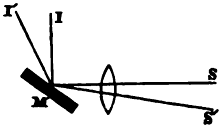
* See this Journal, vol. xlviii, Sept. 1869.

With this mirror making not less than 300 turns in a second, I was greatly surprised to find that the image of the spark on the ground glass, as viewed by the naked eye, was quite unaffected in appearance, looking about the same as though the mirror had been stationary. This experiment, which was repeated daily, gave uniformly the same result, and proved that the total duration of the discharge was incomparably shorter than in the case of the larger jar. When the paper with the black lines ruled on it was used, they were seen equally distinct with the highest as well as with the lowest velocities; and all the evidence went to show that the discharge of this small jar consisted of a *single act*, whose duration was immeasurably short. Knowing well the inestimable value in certain physical inquiries of a source of illumination of this character, a series of more deliberate experiments were now instituted for the purpose of examining in detail its nature, and, if possible, duration.

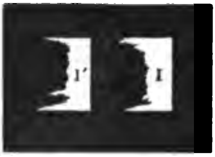
The mirror was made to revolve 300 times in a second, the image received on the ground glass, and viewed with the naked eye, platinum wires $\frac{1}{86}$ of an inch in diameter being used, with a striking distance of five millimeters. The result was as above given, the spark-image being totally unaffected—once only at one of its ends a very small and faint streak was noticed. Replacing the ground glass by plain, and magnifying the image of the spark with an eye-piece, it was now at last certainly ascertained that it was followed by a minute and faint tail or streak situated at its extremities. The illuminating power of this streak was trifling—less than one per cent of that of the unanalyzed body of the spark it belonged to—and its length was hardly much greater than the breadth of the micrometer lines previously employed. The platinum wires were replaced by others of zinc, and, as was expected, the tail was rendered more easily visible, and attempts were made to compare its size with the thickness of single micrometer lines, which proved difficult and uncertain, owing partly to the variable position assumed by the spark-image in the field of the eye-piece. Although for practical purposes the duration of this faint tail or streak is only of slight importance, still for the sake of completeness a new form of micrometer was devised capable of effecting its measurement, and I cannot but hope that the general plan employed may hereafter prove useful in parallel lines of investigation. The point to be gained was to have the micrometer always applied to the object to be measured; the spark-image must carry its own micrometer—must in some way be made as it were to measure itself.

Micrometer.—Let the spark be generated at S, fig. 1; its light, falling on the stationary mirror M, will form a spark-image at I, in the plane of the observing plate. If at the *same* instant a second spark be generated at S′, its image will fall at I′. Let us suppose that during the simultaneous production of the two sparks, the mirror is rotating so rapidly as to be able to draw them partially out into streaks, then we shall have the appearance presented by fig. 2, the distance between I and I′ varying with the original distance between the sparks; and it is evidently possible to diminish this quantity, so that the tail of I should just be in contact with the edge of its companion. In this way, the length of the tail can be measured, it being afterward only necessary to measure on the observing plate the distance of the spark-images apart when seen with the stationary mirror. In actual practice, at S′, I placed a plane mirror, and by varying its inclination with a screw, obtained any desirable separation of the images, without greatly injuring the focal adjustment. A still better arrangement is to remove this mirror, and substitute for it at S′ a small strip of white paper, inclined 45° so as to receive the light of the spark, as its feebler luminosity, straight edge, and the perfection of the joint focus, all tend to increase the accuracy of the results. This paper was supported by an appropriate stand, and was moved till the right distance had been attained.

1.



2.

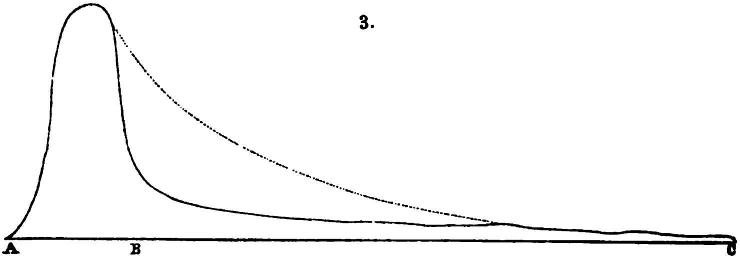


Total duration of the discharge.

As was to be expected, this was found subject to some variation in individual sparks. With zinc points, and a striking distance of one millimeter, the duration varied between ·000001 and ·0000025 of a second, a duration as long as two and a half millionths of a second being somewhat rare. With greater striking distances, or with platinum points, the tail was not so well developed; but sets of more hasty measurements showed that its duration in these cases did not widely differ from the figures above given. With zinc points, and a striking distance of *two* millimeters, a couple of careful experiments gave respectively a duration of ·0000022 and ·0000019 of a second. The room in which the determinations were made was usually not entirely darkened, but kept in something of a twilight condition, which is more favorable for preserving the accommodation of the eye; from time to time these results were compared with those obtained in a dark room, but nothing new of importance was thus elicited.

Although with the improved micrometric method above described an interval of time as small as one millionth, or half a millionth, of a second could, as has been seen, be directly measured, still with its aid I never detected any sign that the *duration of the great body of the spark was other than absolutely instantaneous;* as, however, all the light of the spark is due to incandescent material particles, we must suppose that an infinitesimal portion of time is required for attaining its maximum brightness, and owing to the same reason its disappearance demands another distinct period however excessively minute. Hence, we may represent the luminous effects of the discharge by a curve conforming more or less to that here figured, in which intensity of light is measured in a vertical, time in a horizontal, direction. This curve then, (the unbroken line), serves to give some idea of the relation existing at successive intervals between the luminosity and duration of a single discharge, and its continuity indicates the fact that there is no real interruption at any moment. The curve is of course adapted for that part of the discharge next to the electrodes, or for electrodes that are near together; for in the case where they are distant five or ten millimeters, the part between B and C is not so well developed.

3.

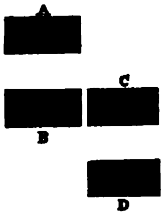


It is this steep peak A B which constitutes what, in the first part of this paper, I have characterized as "the first and most brilliant act of the discharge;" though with a larger Leyden jar (114 square inches), it is neither so steep as in the present case, nor so solitary, being followed by a series of minor elevations, while with a *small jar* the effective luminosity of the discharge is almost wholly concentrated in it. In the present case, then, the far greater brilliancy of the light at the beginning of the discharge practically separates it from what follows, practically constitutes it a first distinct act, and renders its measurement highly desirable. Later, some evidence will be adduced to show that the curve really has a form substantially like that here given, instead of some such one as is indicated by the dotted line.

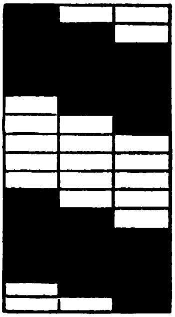
For the purpose of measuring, or at least setting, a limit at one side of the infinitesimal period of time involved, I employed the same general device of black and white lines previously described. But it will now be necessary to make a more *accurate* analysis of their relation to the problem than was given in Part First of the present paper, as I noticed after publication that, owing to an oversight, the statement there printed is partly incorrect, though the results there given are not vastly affected, and may be corrected by reading on the last page, that the discharge was proved to last less than *four*, instead of two, ten-millionths of a second. (Its actual duration I have recently obtained, and state at the end of the present paper.)

If two black lines of a certain breadth, inclosing between them a white line of equal breadth, be illuminated by the spark, and their images formed on the observing plate by the lens and mirror, the three lines will evidently be seen unaltered in appearance; provided, 1st, that the mirror is stationary, or revolving at a sufficiently low rate; or, 2d, the same effect will be produced with a rapidly revolving mirror and a truly instantaneous spark. If, however, the illumination of the spark last sufficiently long so that while A B, fig. 4, represents the first view obtained, the last view shall be represented by C D (moved to the left till superposition has been attained), then, owing to the retention of impressions on the retina, the distinction between the black and white lines will be exactly obliterated, and a tint of gray produced, as can be shown by a construction. In fig. 4 the first and last views *only* are given; but as the action is an unbroken one, we must remember that between them properly belong a great number of pictures, with a gradually increasing displacement. Taking this number, for example, as eleven, then, on completing the construction which is begun in fig. 5 so as to correspond with fig. 4, it will be seen that the result is a gray streak shading into white at its upper and lower boundaries, and that all the interior portions are composed either of resultants produced by adding five parts of black to six of white, or the reverse. And in general, if we set the number of views equal to some odd number greater than unity, we shall obtain for the interior portions $\frac{n-1}{2}$ parts of black, with $\frac{n+1}{2}$ of white, or the reverse; so that the greater the number of views used in the construction, or the more we approach to the real state of the case in nature, the more perfect will be the balance of black and white obtained. And this conclusion is justified by experiment; for if two black sec-

4.



5.



tors, inclosing between them a white sector of equal breadth, are painted on a white circular disc of card-board, and viewed in a mirror through an aperture cut in the same disc, when it is made to revolve, these sectors will be distinguishable until the observing aperture has been widened so that it is equal in breadth to *two* of the painted sectors, when only a band of gray will be seen, uniform in its interior portions, and shading into white at its two extremities, according to the indications of the construction. Furthermore, making the disc experiment afresh, as the observing aperture is gradually widened, it is easy to note the growing obscurity and lack of sharpness in which the sectors become involved, which may hereafter serve to interpret corresponding changes in the image produced by the electric discharge, or explain and give a meaning to their absence.

Instead of using only two lines, the same result can far more easily be attained by ruling paper with a large number of fine black lines, equidistant, and inclosing white spaces of their own breadth, as then the chances for observation are greatly multiplied. A construction made on the same plan, for a set containing a large number of lines of this character, will show that the same law again prevails, that the extremes shade into white, and that all the interior portions are of a uniform gray tint; hence, that when a superposition such as indicated in fig. 4 has been obtained, all the lines will, by the retention of impressions on the retina, be obliterated. Naturally, experiment with the disc gives the same result.

Accordingly, I again used the same set of lines (on paper) mentioned in Part First of this article, and illuminated them with the electric discharge now under consideration. With the mirror revolving 340 times in a second, using platinum points and a striking distance of two millimeters, the lines were still seen with an eye-piece, as bright and clear as though the mirror had been stationary, implying, as the apparatus was then arranged, a duration, for the first act, of less than three ten-millionths of a second, which interval would have been required for destructive superposition. Nothing more could be done with paper, and accordingly I covered a glass plate with lamp-black by smoking, and poured over it a few drops of alcohol, which, acting like a slight cement, enabled me to rule lines on it with a small dividing engine. After many trials and microscopic examinations, a plate was produced with lines black and white of equal breadth, and the spark being discharged behind them, they were brightly illuminated. Their image was thrown on the observing plate, and by using a sufficient magnifying power and counting, it was ascertained that the breadth of the image of a single line, black or white, was $\frac{1}{12}$ of a millimeter. Hence, the time required for their obliteration, with a velocity of 340 per second, was ninety-four billionths of a second (·000000094); still, on experimenting, it was evident that the duration of the discharge was less than this quantity, as the lines were always plainly to be seen.

Duration of the first act of the discharge.

Before finally abandoning the attempt to determine the actual duration of the discharge, another effort was made; a second lamp-black plate was prepared, in which the breadth of the image of a line, black or white, on the observing plate was $\frac{1}{24}$ of a millimeter. These lines were viewed with the terrestrial eye-piece of a small telescope; it enlarged them ten diameters, and care was taken with all the adjustments so that a good clean image should be produced. Platinum wires $\frac{1}{86}$ of an inch in diameter were used with a striking distance of five millimeters. By gradually increasing the weight, it was proved successively that the duration was less than eighty, sixty-eight, fifty-nine, fifty-five billionths of a second; and finally, the lines after growing fainter and fainter, entirely disappeared, giving as the result a duration of forty-eight billionths of a second. In a large number of observations I could detect no discharge lasting during a smaller interval, though the apparatus was now fully capable of making evident much smaller periods of time.

When the striking distance was reduced to one millimeter, the duration was shorter; in the case of $\frac{5}{6}$ of the sparks, the duration was slightly greater than forty-one billionths of a second, the remaining $\frac{1}{6}$ being slightly less than this figure.

With a striking distance of three millimeters, the duration was between forty-one and forty-eight billionths; and when the striking distance was increased to ten millimeters, it was between forty-eight and fifty-five billionths of a second.

An effort was made to make a corresponding set of measurements with brass balls instead of platinum points; and it would seem probable that the duration of the discharge is somewhat increased by their use (or that many of those with shorter durations are suppressed). With brass balls not nearly so many discharges take place in a given time as with points; hence, the work becomes tedious and less certain. The evidence from twenty-six observations, gathered in not less than three hours, went to show that the duration with a striking distance of five millimeters was between forty-eight and fifty-five billionths of a second.

It has thus been shown that the duration of the first act of the electric discharge is in certain cases only forty billionths of a second, an interval of time just sufficient to enable a ray of light to travel over forty feet. This act, however, is only *practically* isolated; from a scientific point of view it is really the distance

A B, fig. 3, which has been measured; and as we are ignorant of the true curve, it might be objected that the real curve might just as well be supposed to be like that given with dotted line. There is, however, experimental evidence to show that this is not the case; for on this supposition, the blurring of the image would begin to be visbile far earlier, i. e., with lower velocities than has been observed. In point of fact, the image remains visibly as distinct as with a stationary mirror till a certain stage, when it begins to be affected, becomes regularly less distinct, and vanishes; between this stage and the final disappearance, there is included an interval of time which is barely accounted for by the gradual superposition of the white and black lines, as I assured myself by parallel experiments with revolving discs, provided with black and white sectors, and an observing aperture of varying size.

Hence it is seen that we have an excellent source of illumination, which has a practical duration of only forty billionths of a second (·00000004); and I am not without hope that it may hereafter be applied to the solution of a number of interesting scientific problems. I may finally add that with another ruled plate, I found it practicable to measure intervals as small as twenty-eight billionths of a second; and the mere act of increasing the focal length of the lens L would admit of the experimenter reaching a quantity as small as ten billionths—probably without much difficulty—though it would be necessary to pay more attention to the correction of the optical part of the apparatus, and the observations would naturally consume threefold as much time.

Duration of the first act, with a Leyden jar having a coating of 114·4 *square inches.*

With the improvements above described, no difficulty was experienced in making this determination, which, as shown in Part First of the present paper, had on a previous occasion defied all my efforts. Platinum points and a striking distance of two millimeters were employed in connection with the coarsest of the three lamp-black plates; but when the mirror made only 183 turns in a second, it was ascertained that the duration of this first act was ·000000175 of a second, or about four times as great as with the small jar and the same striking distance.

New York, June 29th, 1871.

ART. XXIV.—*Memoranda concerning the introduction of the Manufacture of Spelter into the United States;* by JOSEPH WHARTON.

SPELTER, as crude metallic zinc is called in commerce, had never before the year 1859, been produced in America upon such terms as to give hope of its manufacture becoming a settled industry in this country.

Mr. John Hitz in 1838 made enough zinc from the ores of the New Jersey Zinc Co., to supply material for a set of standard U. S. weights and measures in brass, but the quantity produced was small, and the cost extremely high.

The Lehigh Zinc Co. caused to be erected in 1856 a spelter furnace at their mine near Friedensville, Pa., upon the Silesian plan; this furnace, though apparently well constructed, failed to yield any zinc, mainly because its builder, Mr. Charles Hoofstetten, was unable to make or to procure any suitable muffles.

Mr. Samuel Wetherill, the patentee of some valuable improvements in the manufacture of zinc oxide, also experimented in a spirited manner upon the production of metallic zinc, and actually produced some at South Bethlehem, Pa., as early as 1858, but though he persevered for about two years, and made a considerable quantity of excellent spelter—in all I think about 50 tons—the cost price was too high, and his enterprise was finally abandoned.*

Some other endeavors of less significance were also made which need not now be mentioned; sundry details relating to the early American history of spelter-making may, however, be found in the New American Cyclopedia under the head Zinc, vol. xvi, pp. 636 and 644.

The present paper proposes to give some particulars, which even at this late day may possess interest, concerning that attempt to produce spelter in this country which really succeeded in establishing the industry here, upon such a footing as to enable it thenceforth to take even rank with other American manufactures in their struggle against European competition.

Having acquired some practical knowledge of the properties of zinc, by several years experience as general manager of the Lehigh Zinc Co's. mines and zinc oxide works, and having also gathered such information as was possible from books and other sources, I made various trials during 1857 and 1858, to invent some form of furnace which should effect the evolution and condensation of zinc vapor in a larger and more continuous way than was practised in Europe, and which should thus fulfill in a simpler and more scientific manner, what seemed to be the easy theoretical conditions of the problem. Some of these attempts were not devoid of ingenuity; they cost me much toil and money, but they all failed utterly, by reason of my having overlooked one or another of what may be called the conditions of secondary importance. They served very little purpose but to instruct me in the real difficulties of the manufacture, and I revert to them now mainly to point out to my younger or more sanguine readers that it is usually very bad economy to labor over the rudiments of an art which is to be transplanted, repeating perhaps, many futile unpublished experiments of its founders, when it is at all practicable for them to adopt the processes successfully used elsewhere.

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* The first sheet zinc made in America was rolled by Alan Wood & Sons of Philadelphia, from an ingot of Mr. Wetherill's spelter.

In the year 1859, abandoning these original flights, I built for the Lehigh Zinc Co., at South Bethlehem, Pennsylvania, a single spelter furnace of about 45 retorts, upon the Belgian plan and by the aid of several Belgian workmen imported for the purpose. Since it was necessary for permanent success that only conveniently accessible and cheap American materials should be used, the fuel employed was exclusively Pennsylvania anthracite, the retorts and condensers were made by ourselves, mainly from the fire clay of Perth Amboy, New Jersey, and the ore was hydrous silicate of zinc, from the Lehigh Zinc Co.'s mine near Friedensville, four miles south from Bethlehem, Pennsylvania.

This experiment was continued for several months, and was divided into five periods or campaigns. After its close I furnished to the Lehigh Zinc Co., in September, 1859, a report, from which the figures below are extracted; these give the average results of the last three of those periods, and show the expenditures calculated to the 1000 lbs. of the spelter produced.

The price of ore was here assumed at rather more than the cost of mining and hauling to the furnace; the price of coal was that actually paid for the small sizes employed, then relatively less valued than now; the wages were of course high, because but a single furnace was operated, and we were learning, viz:

4,304 lbs. raw zinc ore at $2.50 per 2,240 lbs.,	$ 4.80
7,813 lbs. anthracite coal at $1.75 per 2,240 lbs.,	6.11
Wages, including manufacture of retorts, &c.,	20.45
Clay, &c., and the preparation thereof,	1.75
Repairs of furnace and tools,	6.00
Steam power,	1.00
Rent of buildings,	60
(Superintendance, office expenses, &c., not counted),	
Total cost of 1,000 lbs. Spelter,	$40.71

The entire cost of this experiment, including the importation of workmen, construction of furnace and tools, and all collateral expenses was $3,795.89. The quantity of spelter produced was 34,063 lbs.

That report naturally excited in the minds of the Lehigh Zinc Company, a strong desire to engage at once in the manufacture of spelter, since not only were the technical difficulties in the way of this great prize overcome, and the product of excellent quality, but the cost was within the market price, and there were apparent margins for economizing in several particulars. On the other hand doubts naturally lingered as to the possibility of attaining the expected results upon a large scale, and the financial position of the Company was at that time such as to enforce caution. Both funds and courage were in fact rather lacking, and though I made various propositions, including one to build the desired factory at my own cost, taking pay in a reduction in the price of ore which I would buy to treat in the factory on my own account, no satisfactory arrangement could be immediately made.

Ultimately, however, an agreement was entered into between that Company and myself, on the 13th of December, 1859, by which I engaged for the sum of $30,000, to convey to them a suitable piece of ground in South Bethlehem, Penn., and to erect thereupon by July 1, 1860, a complete Spelter Works, of sixteen Belgian furnaces, each containing fifty-four working retorts; the furnaces to be enclosed in a suitable stone or brick building with slate roof, 155 feet long and 40 feet wide; the establishment to be provided with steam engine and boilers, steam pump drawing water from the Lehigh river, blowers, ore-crushing mill and store room—all these latter to be enclosed in a suitable stone building with slate roof—also to be provided with pottery fully equipped with clay mills and apparatus to make all fire bricks, retorts, condensers, etc., needed in the business, ore-roasting furnaces, air flues and water pipes, railroad into yard, coal bins, etc., and to be in all respects capable of making from the Lehigh Zinc Co.'s selected or lump ores 3,000,000 lbs. of spelter annually. I also bought from the Company 15,000 tons (of 2,352 lbs. each, moist weight) of their selected ore at $7 per ton for the first 5,000 tons, $7.50 per ton for the second 5,000 tons, and $8 per ton, for the third 5,000 tons; the average of which prices was calculated to equal the average price which had been theretofore received for several considerable lots of similar ore, sent by the Company to England. I also agreed to rent the factory to be built as above mentioned, from July 1, 1860 until Jan. 1, 1863 at $3,000, per annum, and at the end of that period to hand it over to the Lehigh Zinc Co., in complete running order for producing the stipulated 3,000,000 lbs. of spelter annually.

This arrangement offered to the Company as nearly absolute certainty as the nature of the case permitted, that they should at small expense and without risk or trouble to themselves be put into possession, after two and a half years, of a complete factory and an established business, while meanwhile deriving a fair profit from the sale of ore, which at that time cost about $2 per ton delivered in the factory yard.*

Upon my side, relying upon the correctness of my own estimates and upon my ability to establish the business, and assuming that the average price of spelter in this country for the preceding twenty-five years (viz: about 6½ cts. per lb.) would be about maintained for the ensuing two or three years, I could fairly count upon a reasonable profit even after making some allowance for mischances.

A severe winter prevented much progress in building until the spring of 1860, though one block of furnaces was actually put up under cover of a tight temporary wooden building; a freshet in the spring destroyed the foundations of some of the furnaces; the thick middle wall separating the backs of the several pairs of furnaces, and supporting the covering arches, was at first made of a semi-refractory red brick of the neighborhood, covered on each side toward the furnaces by about 12 inches of fire bricks; those middle walls melted out, and had to be replaced by solid fire brick masonry. In spite, however, of these and similar difficulties, everything was completed so nearly according to programme, that 1,100,580 lbs. of spelter was made in the new factory before the end of the year 1860; a feat which would have been impossible, but for the precaution which I had taken of importing a number of trained Belgian workmen, who arrived in August, 1860, about the time the works were completed. As the factory worked irregularly in the year 1860, and the furnaces were brought into use gradually, one block after another, as they were finished, I give no details of the operations for that year.

To indicate what manner of difficulties lie in wait for the transplanter of an industry into this country, I may here remark that though the factory as at first planned and built was substantially right in all important points, and my estimates of cost of production were justified in practice, yet a number of adaptations to circumstances or partial changes proved to be necessary: a force of furnace men taken from such laborers as were accessible here, and instructed in the industry, became unruly before they were half trained, and presuming upon their supposed monopoly of the art and my supposed necessities, began to demand extravagant wages and privileges tantamount to control of the works, and were only brought into subordination by the unexpected arrival, in June, 1861, of a second colony of Belgians, whom I had quietly sent for betimes: a manager brought over from England proved unsatisfactory, thus obliging me to take personal charge of everything for the entire term: those dykes against the inundation of foreign spelter, which I had expected from a tariff upon it approaching the average of that upon other imported goods, were prevented by the importers, aided by some American spelter buyers, who disregarded the fact that their interest demanded a home production. Early in 1861, the demand for all goods had become very light in view of the threatening political aspect, and my spelter, though of the choicest quality and a few months before eagerly taken, could not be disposed of except in small quantities and at extremely low prices. A large stock accumulated in my hands, while money with which to continue the manufacture became very scarce.

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* From my Reports to the Lehigh Zinc Company, as General Manager of their mines and works, I find the cost of zinc ore delivered in the yard of their Zinc Oxide Works in South Bethlehem, which adjoined the Spelter works, to have been for the year ending April 1, 1859, $1.66 9–10 per ton of 2,240 lbs. moist weight, and for the year ending April 1, 1860, $1.72 3–10 per similar ton. The average of 9 analyses of representative specimens of the ore delivered to zinc oxide works, at various times, shows 26·60 per cent zinc oxide.

The factory was, however, driven unremittingly, and its operations during the year 1861 were as follows:

		Per diem per furnace.	Per diem per retort.
Days work of 1 furnace,	4,141½		
Days work of 1 retort,	223,548		
Retorts consumed in 1861,	12,986	3·14	·085
Condensers " "	34,425	8·31	·154
Raw ore " "	11,994,794 lbs.	2,897 lbs.	53·66 lbs.
Roasted ore " "	9,879,000 "	2,386 "	44·19 "
Fuel coal " (including steam power, pottery, &c.,)	18,948,273 "	4,577 "	84·76 "
Charge coal consumed in 1861,	3,709,350 "	896 "	16·59 "
Spelter produced, "	3,158,630 "	763 "	14·17 "
Per centage yield of ore counted as raw,	26·33 p. c.		
Per centage yield of ore counted as roasted,	31·97 "		
Loss in weight of Raw ore by roasting,	17·63 "		
Ratio of Coal consumed to Spelter made,	7·17 to 1		
Average duration of Retorts in days,	17·21		
Average duration of Condensers in days,	6.49		

The total amount of wages paid for the year, for all purposes except the office expenses, was $44,113.54, or per 1000 lbs. of spelter produced $13.96.

The total cost of spelter in 1861, including not only ore, coal, pottery materials and wages, but also rent, repairs, contingent and office expenses—every outlay in fact except selling expense—was $34.70 per 1000 lbs. at the factory. The net average price received for spelter sold in 1861 was $42.97 per 1000 lbs. at the factory.

In the year 1862 the supply of ore was of somewhat inferior quality, yet by the sliding scale of price payable under the contract it cost more per ton than in 1861; these disadvantages nearly neutralizing those economies which greater experience and continual diligence rendered possible.

The cost of spelter in 1862, including as in 1861 all items of expense except interest on working capital, but excluding selling expenses or any allowance for my own exertions, was $34.55 per 1000 lbs. at the factory.

The particulars of operations for 1862 were as follows:

		Per diem per furnace.	Per diem per retort.
Days work of 1 furnace,	4,705		
Days work of 1 retort,	258,509		
Retorts consumed in 1862,	13,614	2·89	·053
Condensers “ “	47,870	10·17	·185
Raw ore “ “	14,209,169 lbs.	3,020 lbs.	54·91 lbs.
Roasted ore “ “	12,532,130 “	2,664 “	48·44 “
Fuel coal “ (including steam engine, pottery, &c.,)	26,451,844 “	5,622 “	102·22 “
Fuel coal “ (in Spelter furnaces alone,)	22,236,164 “	4,726 “	86·02 “
Charge coal “	5,296,256 “	1,126 “	20·47 “
New refracting material consumed,	1,974,919 “	420 “	7·64 “
Old do. “ (broken retorts, &c.,)	1,089,132 “	221 “	4·02 “
Spelter produced in 1862,	3,704,676 “	787 “	14·31 “
Per centage yield of ore counted as raw,	26·07 p. c.		
Per centage yield of ore counted as roasted,	29·56 “		
Loss in weight of Raw ore by roasting,	11·80 “		
Ratio of Coal consumed to Spelter made,	8.57 to 1		
Average duration of Retorts in days,	18·99		
Average duration of Condensers in days,	5·40		

The total amount of wages paid in 1862 for all purposes except office expenses (and for brick-making as below stated) was $48,004.09, or, per 1000 lbs. of spelter produced, $12.96.

The above figures, showing coal and refracting material used, and wages expended, as also the sum stated for total cost of spelter in 1862, include the fire bricks of all sorts used in repairs, all of which were made on the premises, but do not include expenditures, receipts and materials for 95,630 fire bricks made in the works beyond its own requirements and sold to other establishments at a slight profit.

The smaller loss of weight by roasting in 1862 than in 1861, the smaller difference in yield as calculated on the ore when raw or when roasted, and the increased consumption of coal, arise from the fact that the proportion of carbonate of zinc which appeared in the ore of 1861 did not exist in that of 1862; the latter being almost exclusively silicate of zinc, an ore more refractory and poorer than the carbonate, and having nothing to lose by roasting but water.

My lease of the factory was extended from January 1, to April 1, 1863, in order to compensate for certain deficient deliveries of ore. On the latter date I surrendered possession to the Lehigh Zinc Co., and have consequently no later statistics than those above given except for the months of January, February and March, 1863, whose details resemble those of the preceding periods so closely that I will give here only the leading figures, viz:

Raw ore	consumed	in first three	months	of 1863,	4,184,544	lbs.
Charge coal	"	"	do.	"	1,349,880	"
Fuel coal,	"	"	do.	"	7,083,798	"
Spelter produced,		"	do.	"	986,080	"

A resumé of the spelter produced during the entire term shows

it to have been in the fraction of	1860,	1,100,580	lbs.
during the year	1861,	3,158,630	"
" "	1862,	3,704,676	"
" 3 months of	1863,	986,080	"
	Total,	8,949,966	"

This weight being not that shown by the daily furnace statements, but the weight actually sold and delivered to purchasers.

I am aware that to give the details here presented their full scientific or technical value, they should be accompanied by reliable statements of the composition of the ores treated, and of the slags thrown out, but no continuous series of analyses was made of either ores or slags, since my duties as superintendent, bookkeeper, and business manager of the establishment prevented a very close attention to its chemistry. Among my analyses, however, are those of 5 specimens of ore at various times in 1859 and 1860, which were of such a nature as to be fairly presentable for samples of the ore treated in the spelter works: these five specimens show an average of 36·07 per cent metallic zinc.

It is to be remarked that these analyses, and also the weights given above of raw ore consumed, are of the moist ore as received from the mine. The moisture in a large quantity of ore set apart as a sample of that to be delivered at the spelter works was 5·53 per cent, but this is less than was sometimes present, particularly in the year 1861 and the spring of 1862.

Nine specimens examined for moisture at various times, and representing with considerable fairness the ore delivered in the last named periods, show an average moisture of 8·83 per cent.

Of slags, I find only two reliable analyses; one made in November and one in December, 1860; from their proximity to each other in time, and from their occurrence in the earliest working of the establishment, they can hardly be presented as representative specimens. It is not, however, to be doubted that the slags were always tolerably rich in zinc, since of the ore treated probably at least ⅓ was silicate of zinc, only the remaining fraction being carbonate of zinc.

The two slags named do not differ widely, and average 11·46 per cent. metallic zinc.

It seems inexpedient to burden this paper with descriptions of furnaces, apparatus or processes, since all were but copies, slightly modified to fit local circumstances, of the well known Belgian furnaces, apparatus and processes. The figures given will enable the metallurgist to compare my results with those of other establishments, while the general success of the enterprise, in face of the oracular opinions of interested experts that zinc distillation required the lambent flame of bituminous coal, and could not be effected with anthracite, that silicate of zinc had not been and could not be made to yield any considerable part of its metal, and that no American clays were capable of withstanding the peculiar trials of a zinc retort, may serve to encourage some of my countrymen in their attacks upon other European monopolies.

A few details of my experience in construction may be useful. Excluding the stone foundation, the air flues leading to furnaces, the cast iron ingot moulds, and the sheet iron charge boxes, each block of 4 furnaces required the following materials, viz:

Ordinary red bricks,	13,000	
9 inch fire bricks,	11,000	
Fire bricks of special patterns,	71,364	lbs.
Cast iron for furnace fronts, doors, braces, &c.,	37,320	"
Wrought iron for straps, bolts, &c.,	1,138	"
Wrought iron for tools (plus 22 lbs. cast steel)	1,267	"

In considering the statements of cost given in this paper, the reader must bear in mind that it is not now possible either to build, or to produce spelter, so cheaply as was done in the years 1860 to 1863, and this not only nor principally because I conducted the business with unusual assiduity and maintained a high standard of efficiency and discipline among the workmen, but mainly because labor is now much higher than it then was, and because no ore of equal quality can now be obtained so cheaply in a spot so favorable for its manufacture.

The quality of the spelter made in this establishment has always been excellent, and has caused it to be preferred above all other sorts for zinc castings, and for all purposes requiring a high degree of purity. In the exhaustive examination of various kinds of zinc, communicated in May, 1860, by Drs. Charles W. Eliot and Frank H. Storer, to the American Academy of Arts and Sciences, my zinc was found to excel all others; the sample No. 4 there mentioned was made by me in the year 1859, in the trial furnace spoken of in the earlier part of this paper.

The Lehigh Zinc Co., since taking possession of the factory, have maintained the high character of its product, and the zinc-rolling mill which they have added to it turns out sheet zinc of the very choicest quality, such as could only be made from spelter of the highest grade.

This excellence results mainly of course from the unusual purity of the ores of Saucon Valley; the silicate particularly, which has always been the predominant ore there, being notably freer from impurities, not only than most ores from other localities, but also than the carbonate which abounded in the earlier history of those mines, or the sulphide which appears more and more as the depth of the workings increase.

At one time, in order to produce a certain quantity of superior zinc for chemical uses, I selected a quantity of the cleanest silicate of zinc, calcined it in a new roasting furnace, rejected, after roasting, all pieces which from discoloration or otherwise appeared suspicious, ground it in a clean mill, and then distilled it in a furnace which had never before been used, rejecting all the first and last products of distillation from each charge in each retort. The zinc thus made, amounting to several tons, went mostly to various chemists, and is doubtless all consumed except a few ingots which I still retain. It was, however, no purer than that examined by Drs. Eliot and Storer, nor is this surprising, since the latter was made in a new furnace from silicate of zinc which had been weathered for a long time, and was thus freed from the intermingled clay which otherwise might have yielded some impurities.

The establishment whose origin is thus sketched is still in successful operation, and though its activity is now limited by reason of an insufficient supply of ore, there is good reason to believe that this difficulty will be overcome when the magnificent pumping apparatus now being erected by the Lehigh Zinc Company shall enable them to mine at greater depths.

The entire spelter and sheet zinc manufacture of the United States, now a large and growing industry, may fairly be said to have sprung from this factory, for not only was it the pioneer in point of time by at least two years, but I believe that neither of the others succeeded until it availed itself of the services of men procured from this establishment.

Art. XXV.—*The Daily Motion of a Brick Tower, caused by Solar Heat;* by Prof. C. G. Rockwood, Ph.D., Bowdoin College.

The observations which form the subject of the following discussion were made in the spring of 1866. Some recent notices of an attempted investigation of the effect of solar heat upon the dome of the Capitol at Washington have induced the publication of the present note; which, though not a perfectly satisfactory solution of the question, it is hoped may still possess some interest, as being, so far as I am aware, the most accurate investigation of the subject that has been made.

The observations were conducted in the south tower of the Sheffield Scientific School in New Haven, Conn. This tower was built during the winter of 1865, but was still unfinished in April, 1866, when these observations were commenced, although all the brickwork was completed. The stuccoing of the outside was not finished until June 1, and during the whole time occupied by the investigation, the presence of the workmen, with scaffoldings, etc., although not vitiating the truth of the results obtained, was a hindrance to that perfect success which might be expected from a repetition of the experiments under the more favorable conditions of a completed tower and more delicate instruments.

The structure in question is a square brick tower, stuccoed on the outside, the exterior surface being much broken up by recessed windows and various architectural adornments. The general plan of the building precluded the use of solid masonry in the tower, which would have been desirable for any structure designed, as was this, to support astronomical instruments. The walls were, however, made unusually heavy, and in order to have as firm a base as possible for the telescope, the upper story was arched with brick, forming a solid and pretty firm brick floor, upon which now rests the stone pier of an equatorial.

The whole tower is surmounted by a revolving wooden turret. The story below the observatory, and immediately beneath the brick arches, is occupied by the works of the tower clock.

The dimensions of the tower are as follows:

Side of the square at ground,	16½ feet.
" " " top of brickwork,	15 "
Thickness of walls at first story,	27 inches.
" " " top of brickwork,	16 "
" " where the arches spring,	20 "
Height to top of turret,	90 feet.
" " brickwork,	80 "
" floor of observatory room,	75 "

The tower is connected by its north side with the main building for an altitude of about 45 feet. Projecting from the south side of the main building, it has its north wall in a line with, and forming part of, the south wall of the building. The whole edifice stands in a position inclined to the meridian, the sides of the building, and consequently those of the tower, having the direction N. 28° 30′ E.

Previous observations elsewhere (at Bunker Hill Monument) had led to the apprehension that such a tower, besides being subject to tremors communicated from the ground, would have a definite and somewhat regular daily motion, dependent upon the influence of the sun's heat in expanding the materials of which it was composed. The object for which this investigation was undertaken was to ascertain whether this motion would affect the use of the telescope or not.

In order to investigate the motion in the present case, two levels were placed at right angles with each other, upon a flat stone embedded in the brick floor of the observatory room (to avoid any undetermined changes which might affect the woodwork), and their indications were recorded from time to time. Any tipping or motion of the tower would of course change the plane of this floor by the same amount, and would be shown by a corresponding motion of the bubble of one or both of the levels. The levels used were:

I. The striding level of a small transit instrument, the property of Prof. C. S. Lyman. This level, supported by its iron stand, was placed parallel to the *front* of the tower, and therefore, approximately east and west. It was read by a scale graduated to hundredths of an inch. Examination with a level-trier gave 1 inch=39″·37 as the value of its divisions.

II. An unmounted Ertel bubble, which rested directly upon the stone, being placed parallel to the *sides* of the tower, and so approximately north and south. It was read by a scale of tenths of an inch, graduated upon the glass, and reading by estimation to hundredths. Prof. Lyman had previously determined the value of the divisions of this level at 1 inch=51″·7, which was adopted in reducing the observations.

The levels were recorded six times during the day, at intervals of about 2½ hours; the first record being between 7 and 8 A. M., and the last between 10 and 11 P. M. The series extended, with some omissions, from April 24th to July 7th; but some of the records being afterward rejected as unreliable, the final results were obtained from the discussion of observations upon 59 days, included between April 24th and July 2d, 1866. It will be noticed that about one-half of this period was before the stuccoing of the tower was completed; and during about two weeks, from May 15th to June 1st, the tower was partially shaded from the sun by the scaffolding necessary to this work.

A third level placed with the others upon the stone floor, and also the levels of a zenith telescope, which was temporarily mounted on a brick pier in the room, were recorded during a part of this time, but as their results were not employed in the discussion, it is not necessary to notice them farther than to say, that in general they confirmed the indications of the principal levels.

Let us now examine briefly what would be the probable motion of a tower thus situated, and then compare this theoretical result with that given by the recorded level readings.

First: suppose an isolated symmetrical tower of homogeneous material, situated at the equator of the earth, and the sun at the equinox. The diurnal circle of the sun then passes through the east and west points of the horizon and the zenith of the tower. In the morning the heat of the sun's rays would expand the east side of the tower, and cause it to lean toward the *west.* As the sun rose toward the zenith, and warmed equally all parts of the tower, it would gradually return to its mean position. In the afternoon, as the east side lost its heat by radiation and the west side was warmed by the declining sun, it would lean toward the *east;* and during the night would return again to the mean position. Thus the motion would be back and forth over a straight east and west line.

Again, suppose the same tower situated at the pole. Then, since the sun's rays strike it during the whole twenty-four hours, and always at the same angle, the tower, leaning always from the sun and always to the same amount, would follow the sun in its diurnal revolution, its top describing a circle about its normal position.

At any station intermediate between the equator and the pole, the figure described by the tower would be neither a straight line nor a circle, but between the two, i. e., an *ellipse,* whose excentricity diminishes as the latitude of the place increases.

In the case under discussion, the tower is in N. lat. 41° 19′, and the sun was near the summer solstice. The sun therefore rose about 30° north of the east point, culminated south of the zenith, and set north of west.

The inclination of the tower, being opposite the sun, would be, in the morning southwest and west, at noon north, at evening east and southeast, and during the night it might be supposed to return in a straight line to its mean position. Since the sun's rays strike the perpendicular sides of the tower more obliquely at noon than at morning and evening, the northward inclination would be less than the westward or eastward, and the curve described would resemble an ellipse, with its minor axis in the meridian, and probably somewhat flattened on the south.

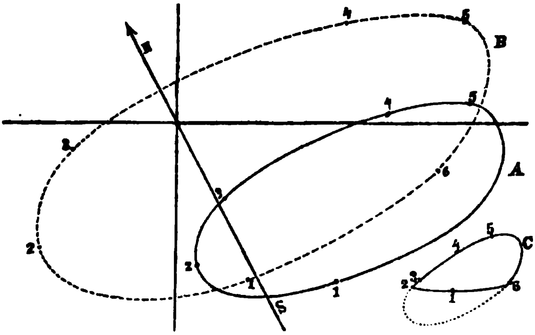
This tower also is not symmetrical nor isolated. It may be considered as a right parallelopiped, standing with its sides inclined to the meridian, and for half its height joined by one side to a large building, which, so far as any effect of the solar heat is concerned, may be regarded as fixed. One side of the tower being thus firmly held by its connection with the building, any motion *toward* or *from* the building would be simply *checked* or *retarded* without change in direction; while to any motion at right angles to this would be added another element, a motion in *azimuth* or a *twisting* of the tower about a vertical line. A scale was prepared in a distant steeple, and the zenith telescope already mentioned was directed upon it, with a view to determine any such azimuthal change. The observations with this arrangement showed a probable daily change of 8″ or 10″ in azimuth, but the instability of the telescope and other causes so far impaired their value, that it was not thought best to incorporate them in this discussion.

The recorded observations give a series of level-readings at certain hours upon 59 days. The most obvious method of combining them is to take the mean of the readings for all the days, as representing the probable motion of the tower for any one day. Thus combined, the means are as follows, the levels being designated by the numerals I and II, and the level readings having been reduced to seconds.

Mean Level Readings.

+East. I.	−5″·76	−0″·95	−1″·57	−7″·62	−10″·67	−10″·48
+North. II.	+5″·64	+5″·03	+2″·97	−0″·37	− 0″·78	+ 3″·38

If now we let these numbers be the abscissas and ordinates of a plane curve, referred to rectangular axes in the direction of the levels, this curve will be the figure described daily by the normal to the plane of the levels or by any vertical line of the tower. It should also be borne in mind that a *south* level reading indicates a *north* inclination of the tower, and vice versa; therefore, to represent the actual motion of the tower the signs of the above means have been changed throughout in plotting the curve. The curve thus obtained is the one marked A in the figure, the points given by the observations being marked by the numerals 1, 2, 3, etc., in order, beginning with the morning observation. It is seen to be an imperfect ellipse, with a major axis of about 12″ and a minor axis of about 5″, and the minor axis coincides nearly with the meridian. It thus corresponds tolerably with what had been anticipated. But the minor axis of the ellipse is not exactly in the meridian, and the curve is somewhat flattened on the southwest and northeast. Apparently the connection of the tower with the main building has checked the north and south motion, and so shortened somewhat the extreme ordinates; as we see that by simply lengthening the ordinates on the northeast and southwest, the curve may be made symmetrical and its minor axis be brought into the meridian.



But it is evident that, in anything which depends so directly upon the sun's heat, the average of *all* days will not give a true result. It is necessary to make a distinction between *clear* and *cloudy* days. From the records of the weather, the observations were therefore separated into two classes, viz: days more than one-half clear and days more than one-half cloudy; and there were found 35 of the former and 24 of the latter. The level readings of these two classes were then tabulated separately, and the mean readings taken as before, to represent the probable motion of any one clear day or cloudy day. The mean readings of the two tables, with the mean times of observation, were as follow:

Mean Level Readings—Clear Days.

	7h 50m A. M.	10h 38m A. M.	0h 59m P. M.	3h 32m P. M.	5h 58m P. M.	10h 39m P. M.
+East. I.	−2″·72	+4″·79	+3″·52	−5″·96	−10″·17	−9″·33
+North. II.	+5″·52	+4″·48	+1″·08	−3″·55	− 3″·86	+1″·61

Mean Level Readings—Cloudy Days.

	7h 47m A. M.	10h 39m A. M.	0h 59m P. M.	3h 33m P. M.	6h 8m P. M.	10h 47m P. M.
+East. I.	−9″·94	−8″·60	−8″·65	−10″·15	−11″·43	−11″·98
+North. II.	+5″·82	+5″·76	+5″·59	+ 4″·49	+ 3″·91	+ 5″·65

These averages, with the signs changed, being made abscissas and ordinates, give the two curves marked B and C, the observations being indicated by numerals as before.

We see at a glance how necessary to a true result was the separation into two series. The two curves have indeed the same general form, but how different their sizes and positions. For clear days the longer axis is about 17″, while for cloudy days it is not more than 4″. The curve for clear days shows the same shortening of the ordinates that was noticed in A, though to hardly so great an amount. But the curve for cloudy days is very much distorted, and no longer resembles an ellipse.

This excessive departure from the normal ellipse can not be attributed solely to the connection with the main building, for any such retarding effect as has been supposed should be greater when the absolute amount of motion was greater, and therefore, should be more evident on the curve for clear days.

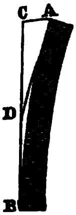
An examination of the figure will, however, suggest another and probably the true explanation. All the points *known* in the curve under consideration, except the one given by the *morning* observation (marked 1), may be found upon a curve nearly similar to the one for clear days. And the distorted position of this point may be accounted for by the supposition (which in fact should not be unexpected), that on a cloudy day the sun would not affect the tower *so early in the day* as on a clear day. Consequently, when the effect begins to be perceptible, the sun has already passed the prime vertical so far as to shine very obliquely upon the northeast side of the tower, and therefore the tower inclines but very little to the southwest of its mean position, and the corresponding part of the ellipse is wanting.

Again, the curve for cloudy days lies considerably farther south and east than the other, instead of being concentric with it. As the south side of the tower is the one most affected by the sun's heat, and moreover has nearly twice the free altitude of the northeast side, it might naturally be supposed to expand most under the influence of the sun's rays; and this, combined with the connection of the northeast side with the building, and its inclination to the meridian, would throw the curve for clear days to the north and west of the other, as it is found to be. It is noticeable also that on clear days the tower is thus maintained out of its normal position by a considerable amount.

Still more, the mean inclination of the sun's rays to the vertical lines of the tower at noon, on the days classed as clear, was 21°, and supposing the intensity of the sun's heat to vary as the sine of the inclination, the minor and major axes of the ellipse should be to each other as sin 21° to sin 90°, or as 35 to 100. Now the minor axis is about 7″, hence the major axis should be from this cause about 20″. It is really about 17″, a discordance which I think can not be considered great, when it is remembered that the tower, being more or less shaded by trees, etc., could not, even on a clear day, be affected by the sun, until the latter had risen some distance above the true horizon (for which the above proportion is calculated), and that the inclined position of the tower to the meridian would probably also affect this element.

The curve deduced from the observations is thus seen to exhibit a sufficient degree of correspondence, with what had been anticipated from theoretical considerations, to confirm the truth of the reasoning; the departures from the perfect ellipse being no greater than can be ascribed to the unsymmetrical position of the tower, its connection with the main building, and other disturbing causes. In all this discussion the varying owers of absorption, radiation and conduction of the materials f the tower have been left entirely unnoticed. They would ndoubtedly have their place in a complete investigation, but o data were at hand for estimating their influence.

If we may suppose the tower to be equally expanded in all arts of its height, the vertical side would be changed to a uniform curve, as AB in the figure; and since the eviation from a vertical is small, the tangent at A ould cut the vertical line BC nearly at the middle oint between B and C. Therefore CD is nearly one-alf the height of the tower, and CA, the distance which e top is moved from its normal position, would be epresented by CD × sin CDA = ½ height × sin of oberved change of level. This gives for the length of CA on n average clear day, 37·5 feet × sin 8″·5 = ·0185 inches, or CA = ·037 inches, the major axis of the ellipse.



But for obvious reasons the upper part of the tower would robably be most affected by the heat; hence CD should proba ly be taken somewhat less than one-half the height, and the ajor axis of the ellipse should be proportionately diminished.

As an indication of the accuracy of the results obtained from uch a series of level readings as the above, it may be remarked, hat two days, which in the reduction of the tables were noticed s showing unusually large easterly and northerly inclinations, ere afterwards found, by reference to the weather record, to ave been marked respectively by a northeast storm and a cool orth wind. The effect of the cold rain or wind in causing ontraction of that side upon which it blew was thus plainly ecorded by the level, and a good illustration afforded of the ccuracy of which this method of investigation is susceptible.

In regard to the practical bearing of this discussion upon the vailability of such towers for mounting astronomical instruents, it may be sufficient, without entering into details, to tate the conclusion arrived at in the present case. This was, hat the motion of the tower was so great and so uncertain as o make it unfit for the support of a meridian instrument, but ot great enough to seriously interfere with the differential easurements for which an equatorial is principally used. The mean hourly change was not more than 1″·2, which, durng the few minutes of an observation, would be insignificant nless extreme accuracy was desired, and might be combined ith the unknown accidental errors in reducing the observations.

In conclusion, I would express my thanks to Profs. Newton nd Lyman of Yale College, to whom I have been indebted for he use of instruments and for valuable suggestions in the conduct of the observations.

Brunswick, Me., July 11th, 1871.

Art. XXVI.—*On the destructive Distillation of Light Petroleum Naphthas, at comparatively low temperatures;* by S. Dana Hayes, State Assayer of Massachusetts.

Under the generic term *naphtha*, as applied to some of the distillates obtained in the arts from petroleum, is included a series of hydrocarbons having specific gravities above 0·742 or between 0·625 (rhigolene) and 0·742 (heavy naphtha), and boiling points varying with the densities from 65° F. to 300° F. These naphthas have distinguishing characteristics by which they are easily recognized and which place them in a class by themselves; and aside from their odors, densities, boiling points, volatility, and solvent powers, a noticeable peculiarity is the absence of *oily* bodies: they do not leave any permanent stain on common writing paper that has been dipped in them, as do all the heavier and oily distillates obtained from petroleum. The redistillation of these naphthas under different conditions produces other hydrocarbons, in which the proportions of hydrogen and carbon are not only changed, but some of these products are *oils* that will stain writing paper like fats, and it is possible to produce crystallizable paraffine from these volatile naphthas by properly conducted distillations.

In the summer of 1861, the writer had occasion to redistill several thousand gallons of light petroleum naphtha, which was entirely free from oily bodies, in cast-iron "stills," heated directly by coal fires and having powerful condensors attached, such as were then common in coal-oil refineries; and it was observed that besides the gases, light vapors, and a greatly diminished volume of naphtha, an unexpectedly large proportion of heavy paraffine oils was obtained; and after the distillations were finished, large masses of separated carbon were found in the stills, as in the ordinary destructive distillations of crude petroleum, or its heavy products.

In 1862,* Professor Bacon of Harvard Medical College observed, when examining a sample of "keroselene," a light naphtha, that had a "specific gravity of 0·640 at 72° F., and when heated in a flask containing scraps of platinum foil it began to boil at about 85° F. As the more volatile parts distilled off, the temperature continued to rise, and at 170° about three-quarters of the liquid had evaporated. It continued to boil freely, but the whole was not converted into vapor until the thermometer had risen considerably above 300°. It is remarkable that keroselene should be so readily and completely volatile at atmospheric temperatures. I found that keroselene and Squibb's ether, exposed in watch glasses, lost equal weights in two and a half and three and a half minutes respectively; and the former evaporated completely in about two-thirds of the time required for the other.”

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* This Journal, Sept., 1862.

This peculiarity of petroleum naphtha has been so often observed in my laboratory, that I have learned to avoid the employment of heat when evaporating solutions, or extracts made in them, for the purpose of obtaining the substances dissolved; because, although these hydrocarbons are exceedingly diffusive, and evaporate entirely and very rapidly in the air at common temperatures, yet when heated above their boiling points (above 5° F., in the case of keroselene), they undergo destructive decomposition, or, if in a flask, destructive distillation, heavier oily bodies being produced which are difficult to remove from the residuum of such evaporations.

Within the past year an apparatus has been erected in Boston, by Mr. Z. A. Willard, for generating gases and hydrocarbon vapors for use in metallurgical operations, that has offered an opportunity to obtain considerable quantities of the oils made from naphtha, distilled at temperatures below 300° F., and I have examined these products with much interest.

Willard's apparatus consists of three or more upright wrought-iron cylinders, having a capacity of several hundred gallons each, standing near a common steam boiler, and which are connected together and with the boiler by pipes that enter at the bottom of each cylinder, ending there and starting out from the top of each again to connect with the bottom of the next; it is thus a system of large iron Woulfe's bottles, the first being connected with a steam boiler. These cylinders or gas generators, when in operation, are about half full of gasoline or petroleum naphtha of the lightest and cheapest kind, which leaves no permanent stain on note paper, while steam at common working temperature and pressure is passing in at the bottom of the first cylinder, bubbling up through and vaporizing the naphtha, then passing into the other cylinders with the same action. The cylinders are provided with glass tube guages, so that the changes occurring inside may be watched, and the whole apparatus and contents are maintained under a pressure of about fifty pounds to the inch when in operation.

In this apparatus the steam and naphtha vapors are held together in the upper part of the cylinders, above the liquid, under pressure, and at a temperature of about 212° F., or much above the boiling point of the naphtha, but never so high as 300° F.; and the decompositions occur in the vapors rather than in the liquid, light uncondensable gases and vapors passing upward, and heavy oil falling down into the naphtha below. The apparatus was operated continuously by pumping in naphtha at intervals as it was consumed, and after the heavy oil had accumulated it was drawn off at the bottom, the largest quantity being found in the first cylinder. It was found that the longer the vapors were held together in the apparatus, heated and under pressure, the more perfect were these decompositions; and Mr. Willard obtained at different times from two to ten per cent. of the naphtha as heavy oil.

The heavy hydrocarbon oil obtained in this way has a dark yellowish-brown color, and smells of the adhering naphtha when fresh; but after standing exposed to the air for a few days, it loses this odor and becomes nearly neutral, or comparatively free from offensive odor. Its specific gravity varies from 0·850 to 0·860, and its boiling point, after it is freed from the adhering naphtha, is above 400° F.

It does not evaporate at common temperatures, leaves a permanent greasy stain on paper, is a good lubricator for machinery, and when redistilled at high temperatures, it breaks up into lighter and heavier liquid hydrocarbons, paraffine, and separated carbon. It is essentially a paraffine oil, like that of the same density obtained directly from petroleum, or its heavy products, by distillation.

When refining petroleum for illuminating purposes, it has been desirable to break up the heavier products and convert them into the light hydrocarbons generally known in commerce, in this country, as "kerosene"; and several forms of distilling apparatus have been devised for this purpose, in which the vapors of these bodies, by being heated above their boiling points, are decomposed or "cracked," first into burning oil and heavy products, and ultimately into burning oil entirely. But Mr. Willard's apparatus demonstrates that light petroleum naphthas, and probably distilled naphthas from coal and other sources, may be "cracked" at a temperature below 300° F. into lighter and heavier products, the latter being paraffin oils that belong to a class of hydrocarbons entirely different from that of the original naphtha.

Through the kindness of Prof. B. Silliman, I have received a copy of his report on the "petroleum from Venango county, Pennsylvania,"* since the first part of this article was written. It is a memoir that has never been published in any scientific journal, containing the results of an extended investigation made in the spring of 1855, being undoubtedly the earliest record of any chemical research on the distillations of this petroleum. And I take the liberty of quoting from it, because at this early date Prof. Silliman found that the products obtained from petroleum are not simply bodies previously existing in the petroleum, but that they are new substances formed by heat and distillation.

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* Report on the Rock Oil or Petroleum from Venango county, Pennsylvania, with special reference to its use for illuminating and other purposes. By Prof. B. Silliman, Jr. New Haven, 1855.

The author says: "The uncertainty of the boiling points indicates that the products obtained at the temperatures named above were still mixtures of others, and the question forces itself upon us, whether these several oils are to be regarded as *educts*, or whether they are not rather produced by the heat and chemical change in the process of distillation. The continued application of an elevated temperature alone is sufficient to effect changes in the constitution of many organic products, evolving new bodies not before existing in the original substance." And further on in the report: "The paraffine, with which this portion of the oil abounds, does not exist ready-formed in the original crude product, but it is a result of the high temperature employed in the process of distillation, by which the elements are newly arranged." When describing the properties of the illuminating oils distilled from this petroleum, Prof. Silliman states the result of an experiment as follows: "Exposed for many days in an open vessel, at a regulated heat below 212°, the oil gradually rises in vapor, as may be seen by its staining the paper used to cover the vessel from dust, and also by its sensible diminution. Six or eight fluid ounces, exposed in this manner in a metallic vessel for six weeks or more, the heat never exceeding 200°, gradually and slowly diminished, grew yellow, and finally left a small residue of dark brown, lustrous-looking resin, or pitchy substance, which in the cold was hard and brittle. The samples of oil employed were very nearly colorless. This is remarkable when we remember that the temperature of the distillation was above 500° F."

It is remarkable that in this early laboratory investigation Prof. Silliman should have noted the production of entirely new bodies by the destructive distillation of petroleum, such as are now only produced in large quantities in manufacturing operations. The "cracking" of petroleum, as a necessary result of its distillations in the large way, was not generally recognized or admitted for several years after this report was written, and even now there are many chemists who consider these as simply *fractional* distillations; but it is only necessary to mix the distillates together again and try to reproduce petroleum, to satisfactorily prove how different the products are from the original substance.

The petroleum upon which Prof. Silliman reported as above did not yield any of the light naphtha to which I have referred, his lightest distillate having a specific gravity of 733, and a boiling point above 400° F., probably because it had been floating on water exposed to the sun, or because it was thick "surface oil." Most of the petroleum, as now obtained from wells in Pennsylvania, yields by the first distillation, either by steam-heat or otherwise, about fifteen per cent of light naphtha, such as is commonly called gasolene, benzine, &c., which is entirely free from any greasy or oily constituent; and this light naphtha, by distillation at comparatively low temperatures as described above, yields about ten per cent of its volume of heavy paraffine *oil*, a new substance produced by heating the vapors above the boiling points of the naphtha, and not simply an educt.

ART. XXVII.—*The Paragenesis and Derivation of Copper and its associates on Lake Superior;* by RAPHAEL PUMPELLY.

BELIEVING that we can arrive at a knowledge of the laws which govern the distribution of ore-deposits only through a careful study of the conditions under which ores occur, and especially of the relations which these bear to their mineral associates, the writer hopes through the present paper to increase the interest in active and accurate investigations of this kind among the many competent men scattered through our mining districts. The paper is divided into three parts:

I. The lithology of the rocks in which the deposits of copper are found.

II. The paragenesis, etc., of the mineral associates of copper.

III. Conclusions from the facts observed.

The second part is the result of a careful study of several thousand specimens. No series was admitted to the list when there was any doubt as to the succession, except where the doubt is indicated by an interrogation point.

I. *Lithology of the Trappean Series.*

In the immediate neighborhood of Portage Lake, the strata composing the "Mineral Range" have a uniform trend of N. 35° E., and a nearly equally regular dip of 55°–60° to W.N.W.

The eastern limit of the "range" is formed by a strongly marked and generally vertical plane of demarkation between the highly inclined cupriferous series of rocks and the sandstones which slope gently to the S.E. This sudden break is considered, with probably the best of reasons, by Foster and Whitney, and afterwards by Rivot, to be a longitudinal fracture accompanied by a dislocation of at least several thousand feet. Foster and Whitney looked upon the sandstone as the equivalent of the Potsdam, while the Geologists of the Canadian Survey refer it to the Chazy, and both authorities agree in considering it to be younger than the cupriferous rock, and of the same age as the sandstone beds, which are comformably superimposed over the trappean series on the west side of Keweenaw Point.

The trappean series consists of beds of melaphyr, varying in thickness from 20 feet to more than 100 feet, the demarkation being frequently defined by the amygdaloidal or epidotic character of the upper portion of each bed.

At intervals, varying from a few yards to several thousand feet, beds of conglomerate occur intercalated in the series.

This is the general character of the country near Portage Lake for a distance of about three miles, measured from the great line of fracture mentioned above, W.N.W. across the formation.

Still farther W.N.W. the rocks are little known, but seem to consist chiefly of sandstones and conglomerates.

The trappean rocks of Portage Lake occur uniformly in beds varying from a few feet to one hundred feet, or more, in thickness. Frequently an appearance of subordinate bedding is observable, arising perhaps from the existence of joints lying parallel to the plane of stratification, which divide the rock into plates a few inches to several feet thick.

The texture of the many varieties varies from compact and sometimes porphyritic, through fine grained subcrystalline or earthy, to coarse-grained and distinctly crystalline. In individual beds the texture is usually found to undergo a more or less gradual change from compact or granular at the bottom to a vesicular or amygdaloidal condition in the neighborhood of the hanging wall.

Green, of various shades, is the dominating color, and next to this brown and dirty red. Light and dark green, mottled or speckled with brown; dirty brownish-green; reddish-gray; and dark green, almost black, are the usual colors.

In the fresh state these rocks may be easily scratched with a knife, but they are exceedingly tough under the hammer, and the force which crushes a fragment often leaves the powder very firmly compacted.

The fracture is generally uneven, or hackly, to imperfectly conchoidal, but in the freshest, and especially in the compact varieties, it is often highly conchoidal. They have an earthy odor often even without having been breathed upon.

Some varieties yield a thick beard of a magnetic iron ore to the magnet, while others contain very little of this mineral.

The ingredients which are visible under the glass, and which seem to be common to all varieties, are a light *green triclinic feldspar* apparently labradorite and chloritic mineral of different shades of green, while the magnet reveals a very variable percentage of a magnetic iron; and in some of the coarser-grained varieties small jet black crystals apparently of augite or hornblende are occasionally visible. The accessory minerals observed, many or all of which are probably products of the alteration of the above constituents, are:

A brick-red foliaceous mineral resembling rubellan, occurring as very minute specks in some fine-grained varieties: it lends a soft rusty-brown appearance to the weathered surface, and speckles the interior with red.

Specular-iron in minute flakes, seemingly more frequent in the coarser-grained varieties.

Calcite in seams, and more frequently in grains and amygdules, especially in the amygdaloidal portion of the beds.

Epidote rarely crystallized; most common in the amygdaloidal varieties, but frequently in seams and impregnations, and nearly always associated with quartz which occurs in amygdules and seams, and also as an indurating medium near the hanging wall of many beds.

Prehnite in amygdules and seams, mostly confined to the amygdaloidal portion of the beds.

A chlorite-like mineral, soft, compact, amorphous, greenish-black, sometimes altered to brick-red, occurring in grains from pin-head to walnut size.

A yellowish-green soft earthy mineral, probably a green earth.

Laumontite and leonhardite in seams and amygdules.

Analcite in amygdules.

Orthoclase in small crystals and massive; in amygdaloidal cavities.

Native copper sometimes in fine impregnations in the fine-grained rock, also in thin sheets in jointing cracks, but chiefly in the amygdules, masses, sheets and impregnations which form the metalliferous deposits in the amygdaloids where it is occasionally associated with native silver.

Datholite massive in the amygdaloidal portion of some beds, and also in small aggregations of microscopical crystals in the same positions.

We have fortunately several recent analyses of different and typical varieties of these rocks, made by Mr. Thomas Macfarlane.*

Of one of the coarser-grained varieties which forms very thick beds several hundred feet west of the Quincy "vein," Mr. Macfarlane says: "It is distinctly of a compound nature, but all its constituent minerals are not large enough to be accurately determined. Conspicuous among them is a dark green chloritic mineral, the grains of which vary from the smallest size to one-fourth of an inch in diameter. In the latter case they are irregularly shaped, with rounded angles, but they are never quite round or amygdaloidal [?]. They frequently consist in the center of dark green laminæ. The mineral is very soft, and has a light greenish-gray streak. It fuses readily before the blowpipe to a black magnetic glass, and it would seem to be the preponderating element in the rock. The other constituents are in very fine grains, and consist of a reddish gray feldspathic mineral, with distinct cleavage planes, and another closely resembling it, in light greenish-gray particles but whether of a feldspathic, pyroxenic or hornblendic nature could not be determined.

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* Canadian Geol. Survey, Report of Progress, 1863–1866, p. 149.

The prevailing color of the rock is dark grayish-green. Hydrochloric acid produces no effervescence with it, even when in the state of fine powder. Its specific gravity is 2·83, and the magnet attracts a very small quantity of magnetite from its powder. The color of the powder when fine is light greenish-gray.

When ignited it loses 3·09 per cent of its weight, and changes to a light brown color. When digested with nitric acid, and afterwards with a weak solution of caustic potash (to remove free silica), it experiences, including the loss by ignition, a loss of 46·36 per cent. This consists of

Silica,	14·73
Alumina,	7·17
Peroxide of iron,	14·87
Lime,	4·47
Magnesia,	2·03
Water,	3·09
	46·36

In the undecomposed residue light-red and dark-colored particles are discernible. On digesting it with hydrochloric acid, and subsequently with a weak solution of potash, it sustains a further loss of 10·6 per cent, which consists of

Silica,	3·48
Alumina,	3·03
Peroxide of iron,	1·98
Lime,	1·76
Magnesia,	·35
	10·60

The undecomposed residue was still found to consist of a light red and a dark-colored constituent. The latter was the heavier, and an approximate separation was accomplished by washing. The dark-colored particles, which could not, however, be freed wholly from the light-colored feldspathic constituent, fused readily to a dark brown glass. To judge from its gravity and fusibility, it would not appear unreasonable to regard it as either pyroxene or hornblende. In quantity it did not, however, exceed one-eighth of the feldspar. The latter fused easily before the blowpipe to a colorless glass, tinging the flame strongly yellow. It would therefore seem to be of the nature of labradorite, although it is only slightly decomposed by hydrochloric acid. Since, according to Girard, neither labradorite, pyroxene nor magnetite, are decomposable by nitric acid, it may reasonably be concluded that the constituents removed by the nitric acid are those of the chloritic mineral. On treating the rock previous to ignition, much of the iron is removed as protoxide.

Although some peroxide is also possibly present, I have calculated the whole of the iron as protoxide, and have moreover, added the difference of the weight between it and the iron estimated as peroxide to the loss sustained by ignition, and put it down as water. In this way the composition of the chloritic mineral, calculated to 100 parts, would be

Silica,	31·78
Alumina,	15·47
Protoxide of iron,	28·87
Lime,	9·64
Magnesia,	4·37
Water,	9·87
	100·00

In these figures the quantity of iron is much greater and that of magnesia much less than in ordinary chlorite. In its composition, and in being easily decomposed by acids, the mineral most closely resembles the ferruginous chlorite of Delesse, (the delessite of Naumann) but differs from it in containing a considerable amount of lime, and in being readily fused before the blowpipe. Assuming, nevertheless, that the chloritic constituent is delessite, and that one-half of the iron removed by hydrochloric acid belongs to the magnetite, then the rock would be composed mineralogically of

Delessite,	46·36
Labradorite,	47·43
Pyroxene or hornblende,	5·26
Magnetite,	0·95
	100·00

By the same method of analysis, Mr. Macfarlane found the rock underlying the copper-bearing bed of the Quincy mine to consist of

Delessite in amygdules and grains,	38·00
Labradorite,	62·00
	100·00

This rock is distinctly amygdaloidal. "The matrix is fine grained, but it is crystalline, and is seen to consist of different constituents. Its color is dark reddish-gray." Its cavities, rarely the size of a pea, are filled with what seems to be the same chloritic mineral which occurs as a constituent of the rock above described.

Mr. Macfarlane also examined the rock which overlies the Albany and Boston conglomerate at the Albany and Boston mine. "It is a fine grained mixture of dark green delessite, greenish-gray feldspar, and reddish-brown mica, some of the laminæ of the latter showing ruby-red reflections. Its specific gravity is 2·81, and the smallest trace only of its powder is attracted by the magnet." He considers the mineralogical composition of this rock to be

Delessite	40·00
Mica	20·00
Labradorite	40·00
	100·00

The rocks, to which the above given analyses refer, are representatives of the three predominating types of the trap of Portage Lake. Mr. Macfarlane's results agree very closely with my own observations on several hundred specimens, aided by the blowpipe, and examination of external characteristics.

Everything goes to show that the normal, essential constituents of these rocks are in their present condition a triclinic feldspar, probably labradorite, and a ferruginous chlorite closely allied to delessite. This composition places these rocks among the typical melaphyrs, the greater specific gravity of the Portage Lake varieties being accounted for by the fact that the sp. gr. of delessite is 2·89, while that of ordinary chlorite ranges from 2·65 to 2·78.

Although the name melaphyr is an unfortunate one, having been first used to designate an entirely different rock, and having been successively applied to others of very various characters, it is now the only distinctive name for the class we have under consideration. All the trap rocks and associated amygdaloids of Portage Lake are varieties of melaphyr.

But I do not doubt that any one who will carefully study the melaphyrs of Portage Lake, and compare them with their equivalents in Keweenaw county, will feel convinced that the melaphyr owes its distinctive character to a process of metamorphism, in which the chlorite resulted, largely or wholly, from the alteration of hornblende or pyroxene. In the more distinctly crystallized traps of Keweenaw county, the pseudomorphic occurrence of chlorite after the hornblende or pyroxene constituent of the trap, may be traced through all the stages to a complete replacement of the latter by chlorite.

The principal varieties of melaphyr on Portage Lake are

1. *Coarse-grained;* in which the crystals of feldspar and grains of delessite are more or less distinct. The color is greenish-gray. It contains generally grains of magnetite and small tabular crystals of specular iron.

2. *Fine-grained;* the constituents, light-green or reddish triclinic feldspar and dark-green delessite, are sometimes distinguishable, but more generally they are not so. The usual color is grayish-green, but it sometimes is speckled with brown

through the presence of small flakes of rubellan; or mixed green and brown, from the oxide of iron produced in the decomposition of some of the constituents. As a rule, the greater the amount of rubellan the less there seems to be of magnetite. In some instances, especially in some of the beds east of the Isle Royale copper-bearing bed, the rock is fine grained and subcrystralline, brilliant black-green, sometimes purplish; slightly shimmering; easily scratched with the knife; contains considerable magnetite, small pieces of rock adhering to the magnet. It weathers rusty gray.

3. *Melaphyr-porphyry;* dark-green, often nearly black; compact with perfect conchoidal fracture; very hard; contains minute crystals of triclinic feldspar.

Amygdaloids.

The amygdaloids are merely varieties of the melaphyr. On Portage Lake they always form the upper or hanging-wall portion of beds of trap, into which they pass by a more or less gradual transition.

It is rare that one finds a bed of trap which does not contain here and there scattered segregations of secondary minerals, especially delessite, but often calcite, laumontite, quartz or chalcedony, prehnite, occupying cavities which are often well defined and spherical or ovoidal, but sometimes wholly irregular in shape, and without definite walls. These enclosures usually become more frequent in ascending from the foot-wall of a bed toward the hanging wall. The plane of demarkation between the amygdaloidal upper portion of a bed and the overlying rock is always well defined. Where they are sufficiently numerous to impress a distinctive character upon the rock, while at the same time the matrix retains the essential features, in regard to color and texture of the parent trap, I have designated the variety

Amygdaloidal Melaphyr.

All the varieties of melaphyr on Portage Lake are subject to this modification, but there is a considerable variation among different beds in regard to the nature of the minerals in the amygdaloidal cavities. In all the varieties, amygdules of delessite, or calcite or quartz coated with delessite, or again spots of epidote, occur here and there in the body of the rock. In some beds the rock is characterized throughout by the presence of laumonite in small amygdules and minute seams.

In the belt occupying 1,000 feet or more on either side of the Isle Royale copper-bearing bed, many of the beds assume towards the top amygdules of delessite and of a green flinty mineral, resembling chrysoprase, coated with delessite. These are gradually succeeded nearer the top by ovoidal, lenticular or irregular amygdules, from the size of a bean to several inches in diameter of prehnite, greenish-white, or tinged with pink generally amorphous, but often with a radiating structure, and sometimes slightly impregnated with native copper.

The portion of the bed nearest the hanging wall is often highly amygdaloidal, while the matrix has at the same time a different degree of hardness, texture and color, and often a different mineralogical constitution from the parent trap. These varieties form the

Amygdaloids proper.

The amygdaloids are the most highly altered form of the melaphyr, and present themselves under a variety of characters in different beds and in different parts of the same bed. The colors of the matrix are different shades of brown or red, and of green, or of these mixed; its texture varies from fine grained or sometimes subcrystalline to compact; and its hardness ranges from that of limestone to that of quartz.

Two quite different kinds of amygdaloid occur on Portage Lake, both separately, and intimately associated in the same bed, and are easily distinguished by their different colors, the one being brown and the other green.

The brown, which exhibits the amygdaloidal character in its highest development, has a chocolate-brown to dirty red matrix, which generally is easily scratched with the knife, but is sometimes indurated and hard; it has a fine grained to subcrystalline texture, and now and then contains minute reddish crystals of feldspar, and fuses easily to a dark-green and somewhat magnetic glass.

The amygdules in this variety are more generally spherical, but often somewhat irregular and connected, and more rarely long-cylindrical, and then usually perpendicular to the plane of bedding. The contents of these cavities, for they are very rarely empty; are laumontite, leonhardite, calcite, quartz, a soft green mineral, apparently green-earth, delessite (more rarely), native copper, epidote, prehnite, analcite, orthoclase. In places one, in others another of these, predominates; generally several are associated.

The green variety is a very fine grained to compact light grayish-green rock. It is generally very hard, striking fire under the steel. Its constituents are very largely free silica, and a green mineral which has been generally taken for epidote, but which is so minutely disseminated as to render it difficult of determination. Small pieces of the rock fuse easily on the edges to a dark enamel which gelatinizes with acids. These beds are called epidote " veins," and they are probably in many instances, at least, an intimate mixture of quartz and epidote, though in otherwise nearly similar beds, the green mineral is soft, and is probably either a green-earth or a chlorite.

The cavities in this variety are often less regularly defined in shape than in the brown amygdaloid. The enclosed minerals are quartz, epidote, calcite, delessite, prehnite, laumonite, green-earth, analcite, native copper, orthoclase. These two varieties of amygdaloids often occur together without any well defined lines of separation, the bed being made up of irregular masses of the two rocks. In places, however, the brown amygdaloid forms a band one to two feet thick on the hanging wall, with a rather abrupt transition into the green amygdaloid underlying it; I have never observed the reverse.

Some beds have an exceedingly mixed character; the amygdaloidal portions are associated with massive segregations of calcite, quartz and epidote, and are traversed by seams and irregular veins of these minerals; this structure is especially noticeable in the beds worked for copper. A somewhat similar structure occurs in other beds on a smaller scale, giving to them a brecciated or even a conglomerate-like appearance, which seems, however, to be due to purely metamorphic action; the best example of this is in the "Ancient pit" bed on the Shelden and Columbian property.

Conglomerates.

The conglomerates of Portage Lake differ from each other but little, if at all, in lithological characteristics. The pebbles vary from the size of a pea to one foot or more in diameter, being coarser in some beds than in others. The different beds vary in thickness from mere seams to several hundred feet, and the same bed often varies greatly in width.

The pebbles, in most of the beds on Portage Lake, consists almost exclusively of varieties of non-quartziferous felsitic porphyry; two kinds predominate; one of these has a chocolate-brown to liver-brown, subcrystalline to compact, almost vitreous, matrix containing very scattered minute crystals of triclinic feldspar of the same color as the base. The other and rarer variety, also non-quartziferous, has a chocolate-brown, compact to minutely crystalline matrix, in which lie crystals, $\frac{1}{8}$–$\frac{1}{2}$ inch long, of a flesh-colored triclinic feldspar.

In some beds there appear pebbles of a flesh-red rock, composed almost entirely of granular feldspar, containing small specks of a black undetermined mineral. In some instances the feldspar is wholly triclinic, in others the twin-striation is frequently absent. This variety of pebble is altogether absent in some beds, at least where they are opened, while in others they predominate, as in the Albany and Boston Conglomerate. Pebbles of compact melaphyr and of melaphyr amygdaloid also occur, but are quite subordinate in number to those already enumerated.

The normal form of cement is a fine grained sandstone, composed apparently of the same material as the pebbles. Often the cement is very subordinate in volume, the pebbles touching each other. Frequently, however, the reverse is the case, and often the sandstone forms layers from less than an inch to many feet in thickness.

The original character of the cement is often entirely lost; the interstices between the pebbles are sometimes, though rarely, empty; in places the sand is associated with oxide of iron, chlorite, a white talc-like mineral, carbonate of lime, or it is entirely replaced by calcite, chlorite, epidote or even native copper.

It is a remarkable fact that while all the conglomerate beds near Portage Lake are free from pebbles of quartz-porphyry, those in the neighborhood of Calumet are characterized by pebbles rich in grains of quartz. This abrupt change takes place about six miles N.E. from the lake.

Different horizons of the Portage Lake series of rocks are marked by certain distinguishing lithological characteristics, which, without in any instance being peculiar to a given horizon, still serve to mark decidedly those parts of the series where they are, respectively, most frequent.

Thus, to begin toward the eastern part of the field, from the neighborhood of "Mabbs' vein" to within, say, 1,000 feet E. of the Isle Royale "vein," there is a tendency, among the different traps, to a compact or fine grained texture with a dark-green, almost black, color, sometimes slightly mottled, especially on the weathered surface. The fracture is brilliant, and the trap contains enough magnetite to cause small bits of the rock to adhere to the magnet.

From this region till 1,500 feet or more west of the Isle Royale copper-bearing bed, the upper portion of very many of the beds have the amygdaloidal cavities filled with a light-greenish white or pale pink prehnite, which sometimes, for a width of 2 to 6 feet, form from 10 to 40 per cent of the rock, and lend it a very characteristic spotted appearance.

During the next 2,000 feet or more, the traps have frequent seams 3 to 20 inches thick, consisting of distinctly individualized triclinic feldspar, delessite, prehnite and specular iron; these occur both parallel to the plane of bedding and oblique to it. The traps through a portion of this distance are frequently impregnated with epidote, as is also the cement of the conglomerate beds.

On the "Dacotah" property we come to a belt of the formation in which many beds have a tendency to a coarse-grained, crystalline texture, and in some the character is highly developed, giving the rock, at a distance, almost the appearance of a chloritic granite. Still farther west, on the "Southside" property, the brown amygdaloids often present a scoriaceous appearance which is quite characteristic.

Some, at least, of these features, are traceable for miles in the longitudinal extension of the zones in which they occur. Thus the prehnitic amygdaloid of the Isle Royale series, is found in the N.E. extension of this zone, near where the road to Eagle river crosses the line between Townships 55 and 56 N., or about 7 miles from Portage Lake.

The coarse-grained melaphyr of the "Dacotah," is found extensively developed in the extension of the same zone on the South-Pewabic, Quincy and St. Mary's properties. The brown amygdaloids of the "Southside" reappear with their peculiar scoriacious structure in the South-Pewabic and Hancock beds, and in the trenches on the St. Mary's, and have been considered the equivalents of the "Ash-bed" rocks of Keweenaw county, which they resemble.

[To be continued.]

ART. XXVIII.—*Observations on the Color of Fluorescent Solutions;* by HENRY MORTON, Ph.D., President of the Stevens Institute of Technology.

As the result of a series of experiments to be presently described, I have come to the curious conclusion that all the familiar fluorescent solutions, such as the tincture of turmeric, of agaric, of chlorophyl, and the solution of nitrate of uranium, emit light of the same color by fluorescence, namely, blue identical with that developed by acid salts of quinine. This blue, however, as is well known in the case of quinine, is not of a single tint or refrangibility, but yields a continuous spectrum, in which the more refrangible rays predominate.

My attention was first drawn to the subject by observing that a specimen of mixed asphalt, which is here largely used in the preparation of pavements, yielded a light-yellow solution with alcohol, which fluoresced blue, and an orange solution with turpentine, which fluoresced green. It at once occurred to me that the green color was simply due to the absorptive action of the colored solution, and not to the development of green rays. Examined with the spectroscope, the seemingly green fluorescence showed no increase in the green or yellow part of the spectrum, as compared with the blue fluorescence, but only an absorption of the red and violet ends. When, however, a piece of fluorescing canary glass or solid nitrate of uranium was examined, the green light was (as is well known) largely augmented. I also found that when, by filtration through animal charcoal, the solution in turpentine was reduced in color, the green tint of the fluorescence disappeared in a corresponding degree. This alone would, however, have proved nothing, as a green fluorescing matter might have been absorbed by the charcoal, but in connection with the spectroscopic result it was of interest.

I next took up for examination the tincture of turmeric. This is set down in standard works, such as those of Du Moncel and Becquerel, as fluorescing red. This solution, when concentrated, has a rich orange-red color, and the jacket of a Geissler tube being filled with it, all the light reaching the eye, from the electric discharge within, is of a deep orange or red color. If, however, the solution is simply diluted until its color is reduced to a rich yellow, the fluorescence appears green. The same result follows from filtration through bone black, with a marked increase in the amount of fluorescence visible, as the light-absorbing coloring matter is removed. By continuing the decoloration until the liquid is colorless or of a very light tint, its fluorescence is distinctly blue.

The results with the spectroscope when it was applied to this substance, were the same as with the solution of asphalt. Such also is the case with tinctures of chlorophyl, which, when fresh and green, gives apparently a green light, and, when old and brown, a gray color.

Finally, I took up the nitrate of uranium, about which such contradictory statements have been published. This salt in its solid state gives a brilliant green fluorescence, whose spectrum is figured by Becquerel, and abounds in green rays; but in solution it gives a very feeble fluorescence, far inferior to that of turmeric, and of no more green tint than would be due to its yellow color. So in fact says also the spectroscope.

From these results it would seem that the molecules of fluorescent bodies *in solution* are not capable of restricting their vibrations to limited ranges, but move at rates corresponding with all refrangibilities, having simply an excess of the higher ones, though the same substances in the solid state may act quite differently, as in the case of nitrate of uranium, and possibly the fluorescent material in the asphalt, which may be related to the solid hydro-carbon fluorescing green, which Becquerel mentions (*La Luminere*, tome i, p. 382).

In this general connection let me mention that I have observed that while the acid salts of quinine generally are fluorescent, the chloride is not, and that hydrochloric acid will decompose the acid sulphate so as to destroy its fluorescence.

There are several other points in connection with this and the foregoing subject, which I must leave for a subsequent discussion.

July, 1871.

P. S.—Aug. 1st. I have just obtained results with turmeric, which seem to indicate that its fluorescence is due to the presence of a substance not yet observed, soluble in water, and without any color.

ART. XXIX.—*Mineralogical and Chemical Composition of the Meteoric Stone that fell near Searsmont, Maine, May* 21, 1871; by J. LAWRENCE SMITH.

IMMEDIATELY after the fall of this meteoric stone a portion of it was placed in my hands for examination. The circumstances accompanying its fall, as well as its physical characters, have been described in the last number of this Journal by Prof. Shepard (p. 133).

It resembles very closely the Mauerkirchen stone that fell in 1768, the crust of the specimens corresponding quite closely to that in thickness and appearance; the Mauerkirchen stone, however, has not well-marked globules like that of Searsmont; in this respect it corresponds more nearly with the Aussun, as already stated by Prof. Shepard.

The specific gravity of the specimen examined was 3·701.

The nickeliferous iron and stony matter were separated mechanically for analysis. One hundred parts of the meteorite gave

Stony matter (including a little sulphuret of iron)	85·38
Nickeliferous iron	14·62

The iron afforded:

Iron	90·02
Nickel	9·05
Cobalt	·43

Phosphorus and copper were not estimated. The stony part, treated with a mixture of hydrochloric and nitric acids, gave:

Soluble in the acid	52·3
Insoluble " "	47·7

The soluble portion afforded:

Silica	40·61
Protoxide of iron	19·21
Magnesia	36·34
Sulphuret of iron	3·06

Leaving out the sulphuret, which is obviously only a mechanical mixture, this soluble part is evidently an olivine,—which is almost invariably the case with soluble portions of meteoric stones.

The insoluble part was composed as follows:

Silica	56·25
Protoxide of iron	13·02
Alumina	2·01
Magnesia	24·14
Alkalies, NaO, KO with trace of LiO	2·10
Chrome iron, small black specks	not estimated

The above analyses give for the composition of the stone:

Nickeliferous iron	14·63
Magnetic pyrites	3·06
Olivine	43·04
Bronzite, a hornblende, with a little albite or orthoclase, and chrome iron	39·27

With the bronzite there may also be enstatite, which would be confounded with the former, if existing in the stone.

ART. XXX.—*Discovery of a new Planet;* by Prof. C. H. F. PETERS. From a letter to one of the editors, dated Litchfield Observatory of Hamilton College, Clinton, Oneida Co., N. Y., July 27, 1871.

A small planet, the 114th of the group of asteroids, was discovered here in the night from the 23d to the 24th inst., and the following accurate positions hitherto have been obtained of it:

1871.	Ham.Coll. m.t.			App. α (114)			App. δ (114)			
	h	m	s	h	m	s	°	′	″	
July 24.	15	14	45	21	43	27·85	−10	12	16·8	(by 6 comp'sons with Schj. 8925)
" 26.	12	18	4	21	42	8·35	−10	20	26·0	(by 12 " " W. 21 h. 954)

Hence follow the daily motions resp. $-42^s\cdot3$ and $-4' 21''$. The magnitude of the planet was estimated this morning in a very fine sky to be 12·3. As it is still about a month yet until opposition, it will become considerably brighter. The planet *Fortuna* (19) runs nearly parallel to it, distant only one degree, being, however, of the 9th magnitude.

ART. XXXI.—*On a new Planet;* by JAMES C. WATSON. From a letter to one of the editors, dated Observatory, Ann Arbor, August 7, 1871.

I noticed last night a star of the tenth magnitude near Weisse XXI, 462, and a single comparison gave the following place:

	Ann Arbor M. T.	α	δ
1871, Aug 6.	$10^h\ 40^m$	$21^h\ 21^m\ 9^s\cdot90$	$-12°\ 30'\cdot1$

A subsequent comparison showed that it had moved, and the following observations were made:

	Ann Arbor M. T.	(115) α	(115) δ	Comp.
1871, Aug. 6.	$12^h\ 24^m\ 4^s\cdot6$	$21^h\ 21^m\ 4^s\cdot64$	$-12°\ 30'\ 6''\cdot3$	4
6.	14 3 36·1	21 20 59·77	12 29 57·6	7
6.	14 59 1·1	21 20 57·19	−12 29 53·5	5

Daily motion, $\Delta\alpha = -69^s\cdot5$ $\Delta\delta = +1'\ 59''$.

The planet shines like a star of the tenth magnitude.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the existence and formation of Salts of Nitrous Oxide.*—The reduction of an alkaline nitrate to nitrite by means of sodium was observed by Schönbein, but the further action of the metal upon the nitrite itself has not hitherto been studied. Divers finds that an amalgam of sodium reduces the nitrite to a salt of nitrous oxide, the successive stages of the reaction being represented by the equations—

$$\mathrm{Na\,N}\Theta_3+\mathrm{Na}_2=\mathrm{Na\,N}\Theta_2+\mathrm{Na}_2\Theta,$$
$$\mathrm{Na\,N}\Theta_2+\mathrm{Na}_2=\mathrm{Na\,N}\Theta+\mathrm{Na}_2\Theta,$$

So that four atoms of sodium are required for the reduction of one molecule of the nitrate. The reduction of the nitrite is accompanied by the evolution of pure nitrous oxide, and the author explains this by the mutual reaction of two molecules of the new salt according to the equation—

$$\mathrm{Na\,N}\Theta+\mathrm{Na\,N}\Theta=\mathrm{N}_2\Theta+\mathrm{Na}_2\Theta.$$

After neutralization by acetic acid, the alkaline liquid gives a yellow pulverulent precipitate with argentic nitrate. This precipitate has the formula, $\mathrm{AgN}\Theta$: it is almost as insoluble as argentic chloride, and may be washed with hot water without change. Light does not decompose this salt; ammonia and ammonic carbonate dissolve it; and acetic acid precipitates it from the solution unchanged. Dilute nitric and sulphuric acids dissolve the salt without immediate decomposition; alkalies precipitate the salt unchanged. It is instantly oxidized by concentrated nitric acid, with production of copious red fumes. Soluble chlorides and sulphuric acid also decompose it. When heated to redness, pure silver finally remains, nitric oxide, metallic silver and a little argentic nitrate being at first formed. When the alkaline liquid containing the sodic salt is neutralized with dilute nitric acid, it gives precipitates with various other metallic salts. The author promises a farther investigation of this very interesting subject, and meantime purposes to call the new acid, $\mathrm{N}\Theta\mathrm{H}$, either *hypo-nitrous* or *hydro-nitroxylic* acid.—*Proc. Royal Society*, xix, p. 425. W. G.

2. *On a remarkable group of Mercurial Colloids.*—By the action of mercuric chloride upon an alkaline solution of acetone, and submission of the mixture to dialysis, Reynolds has obtained a compound of mercuric oxide with acetone, having the formula $\{\mathrm{C}\Theta\,(\mathrm{CH}_3)_2\}_2\mathrm{Hg}_3\Theta_3$. This substance forms the type of a new and curious group of organic bodies distinguished by their essential colloid or gelatinous character. A solution of the acetone compound, containing five per cent., remains fluid, if pure, for twelve or fourteen days, and then sets to a firm jelly. The same result is produced in a few seconds by the addition of very minute traces of various acids, alkalies and salts. Even some insoluble

powders, like calcic carbonate and alumina induce pectization. Elevation of temperature quickly produces the same effect: thus, with a five per cent solution, a firm jelly is produced by heating to 50° C. The solution, when evaporated to dryness, yields a resinoid mass of the anhydrous compound. By the action of alcohol upon the one per cent solution, the author obtained what Graham termed the *alcosol* of the new body. This gelatinized by long boiling to form the *alcogel.* Acetone-mercuric oxide appears to be an extremely feeble but well marked tetrabasic acid. The dry salts are resinoid bodies very difficult to obtain in a state of perfect purity. Several other ketones of the fatty acid series are capable of forming compounds analogous to that described above. The higher compounds are, however, insoluble in water, so that it is difficult to obtain their colloidal hydrates or hydrosols. The anhydrous butyrone compound has the formula $\{\text{Є}\Theta\,(\text{Є}H_3)_2\}\,Hg_3\,\Theta_3$. Elthylic aldehyde forms with mercuric oxide a white non-crystalline compound, but does not give a colloid liquid.—*Proc. Royal Society*, xix, p. 431. W. G.

3. *On a new Synthesis of Acids.*—Von Richter has given a new method of forming organic acids likely to be fertile in interesting results. This method consists in acting upon $N\Theta_2$ compounds with potassic cyanide so as to produce the corresponding cyanides, which are then to be boiled with an alcoholic solution of caustic potash as long as ammonia is evolved. The liquid then contains an organic salt of potassium, from which the acid may easily be obtained. Thus, in the case of bromo-nitrobenzol we have

$$\text{Є}_6H_4Br\,N\Theta_2+K\text{Є}N=\text{Є}_6H_4\text{Є}y\,Br+KN\Theta_2,$$

this being the only part of the process which is really new. When treated in this manner, ortho-bromonitrobenzol (fusing point 125° C.), yields ortho-bromobenzoic acid, $o\text{Є}_7H_5B_2\Theta_2$. Meta-bromonitrobenzol (fusing point 56° C.), in like manner yields meta-bromobenzoic acid, $m\text{Є}_6H_5B_2\Theta_2$, while para-bromonitrobenzol (fusing point 37° C.) does not react with potassic cyanide. The corresponding chloronitrobenzols were also studied. Orthochloronitrobenzol (fusing point 84° C.) yields orthochlorobenzoic acid, $o\text{Є}_6H_5Br\,\Theta_2$. On the other hand, a chloronitrobenzol (fusing at 46° C.) gave chlorosalylic acid, which, when fused with potash, yielded salicylic acid.—*Berichte der Deutschen Chem. Gesell.*, iv, p. 457. W. G.

4. *On Gallein.*—When pyrogallic acid is fused with phthalic acid, hydrous, or better anhydrous, the fused mass dissolved in water yields a new coloring matter in small granular crystals, which Baeyer terms gallein. The new substance is brown-red by reflected and blue by transmitted light, and when obtained by evaporating its solution to dryness, exhibits a peculiar yellow metallic lustre. Water dissolves it with difficulty, giving a red, alcohol easily, giving a dark red, solution. Caustic potash dissolves it with a magnificent blue color, which after some time

becomes dirty; ammonia gives a violet solution. The author remarks that gallein closely resembles hæmatein, which by fusion with caustic potash yields pyrogallic acid. In like manner, as hæmatein, with reducing agents, yields hæmatoxylin, which may again be oxidized to hæmatin, so gallein may be reduced to gallin, a beautifully crystallized substance, which, when moistened with ammonia, again yields gallein. Stuffs mordanted with alumina or ferric oxide are dyed red by gallein, the color being intermediate between that of logwood and brazilwood. The constitution of gallein appears to be represented by the formula $\text{Ꞓ}_{18}\text{H}_{17}\Theta_{7}$: it appears clearly to belong to the family of the coloring matters of logwood and brazilwood, and is therefore the first artificial dyestuff of this group. Gallin has probably the formula $\text{Ꞓ}_{18}\text{H}_{16}\Theta_{6}$: it crystallizes in beautiful lustrous rhombohedrons and prisms. It dyes mordanted stuffs like gallein. When gallein is heated with 20 parts of concentrated sulphuric acid to 200° C., a new substance is formed, which, when purified, presents a bluish-black mass, and which Baeyer terms cœrulein. This body dissolves in hot anilin with a magnificent indigo-blue color. The solution, after adding a little acetic acid, dyes wool indigo-blue. The formula of cœrulein is $\text{Ꞓ}_{18}\text{H}_{10}\Theta_{6}$. By reduction, it passes into cœrulin, which dissolves in ether with a yellow color, the solution exhibiting a beautiful green fluorescence. Cœrulin appears also to be formed directly by the action of sulphuric acid upon gallin. Cœrulein dissolves in alkalies with a green color, and gives a green lake with the earths. Stuffs mordanted with alumina are dyed green; those with ferric oxide brown; the colors appear to be as fast as those of madder. The author points out its resemblance to the Lo Kao of the Chinese. Phthalic acid heated with resorcin yields two coloring matters, fluorescein and fluorescin. The former dyes silk and wool of a beautiful yellow without mordants, and exhibits in solution a magnificent green fluorescence. The author promises a further investigation of this interesting and possibly important subject.—*Berichte der Deutschen Chem. Gesell.*, iv, p. 457 and p. 555.

W. G.

5. *Decomposition of Chromite;* by R. HITCHCOCK.—Chromite is one of the most difficult minerals to decompose, and, although there have been many processes given to effect its analysis, they have generally accomplished the purpose rather unsatisfactorily.

The process given by F. W. Clarke, and published some time ago in this Journal, wherein potassic di-sulphate and cryolite are used, undoubtedly effects the decomposition of the ore; but the amount of sulphate and cryolite required is so great, and the chromium dissolves in such a form, that I have never been able to obtain tolerable results by this method.

A number of experiments have convinced me that the process given below is equal, if not superior, to any I have yet tried, both in accuracy as well as rapidity of manipulation. The process is this: place about 0·3 grm. of the mineral in a capacious platinum crucible, add a piece of ammonic-fluoride about the size of a pea; moisten the whole with a few drops of concentrated sulphuric acid, heat gently until the free acid is expelled. Add now a small piece of potassic disulphate, and bring the mass to a tranquil fusion, maintaining it so for a few moments. Allow to cool, and add a mixture of four parts of potassic and sodic carbonates with one of nitre; fuse gradually, and when the mass becomes tranquil maintain it fused for about fifteen minutes. If cooled by placing the crucible on a plate of cold iron, the mass is readily detached. It is then dissolved in boiling water, and the solution filtered from the residue of iron, which still retains some chromium, and must be again fused with the mixture of carbonates and nitre above given. Sometimes this second fusion requires to be repeated, but for practical purposes this is unnecessary if the previous operations have been well conducted. The bulk of all three filtrates need not be over 200 c.c. The chromium may be estimated by cautiously acidifying the solution, reducing the chromium to the state of sesquioxide by means of sulphurous acid solution, and precipitating by ammonic hydrate. If the Bunsen method of filtration is used, the large amount of alkali present does not materially affect the results. If manganese is present in the ore, it may be determined from the alkaline solution. One advantage of this method is, that there is no troublesome evaporation required to separate silicon.

Results of parallel analyses:

1.	Chromite =	·2888	per cent Cr_2O_3	50·450
2.	"	·2868	per cent Cr_2O_3	50·627
				·177

I am confident that with more experience still better results may be obtained.

II. Geology and Natural History.

1. *Address to the American Association for the Advancement of Science*, by Thomas Sterry Hunt, LL.D., on retiring from the office of President of the Association, Indianapolis, Aug. 16, 1871. 62 pp. 8vo.—Dr. Hunt takes for the themes of his address, first the geology of the Appalachians, especially the history of researches and views with regard to the New England section of this chain; and secondly, the origin and nature of the changes which crystalline rocks have undergone; setting forth under each the labors of others in connection with his own, and also the conclusions to which he has been led. He first divides the crystalline rocks of the chain into three series, draws out the distinctive lithological characteristics of each, and maintains that they belong to different geological eras. They are—

I. The *Adirondack or Laurentide Series*, which is marked by "firm granitic gneisses, often very coarse-grained, and generally reddish or grayish in color," often hornblendic, and little micaceous, and including great beds of magnetic iron ore, and much graphite; but without argillites, or slates containing staurolite, andalusite or cyanite.

II. The *Green Mountain Series*, characterized, he observes, by a fine-grained petrosilex or eurite, which often passes into a true gneiss that is ordinarily more micaceous than the typical Laurentian gneiss, and not very coarse-grained, the color grayish or pale greenish instead of reddish; also by diorites, epidotic and chloritic rocks more or less schistose, steatite, dark colored serpentine, with some slaty hematite or magnetite; also micaceous quartzites and argillites, often unctuous in feel, though not magnesian. Chrome, titanium, nickel, copper, antimony and gold are frequently met with in this series.

III. The *White Mountain Series*, characterized by well-defined mica schists and interstratified micaceous gneisses, the latter often light-colored, fine or coarse-grained and sometimes porphyritic: the mica schists richer in mica than those of the Green Mountain series; also micaceous quartzite; hornblendic gneisses and schists; also crystalline limestones accompanied by pyroxene, garnet, idocrase, sphene and graphite, like the limestones of the Laurentian, but often intimately associated with highly micaceous schists containing staurolite, andalusite, cyanite and garnet, and sometimes highly plumbaginous. The rocks are intersected by granite veins containing tourmaline, beryl, lepidolite, and occasionally tinstone and columbite, only the first of these minerals occurring, as far as known, in the Laurentian gneisses.

After thus dividing lithologically the rocks into these three series, Dr. Hunt endeavors to trace them southwestward along the Appalachians, through the descriptions of other geologists; and later in his address, he uses the same lithological evidence to divide off the crystalline rocks of other continents. The evidence as to the different ages of the Green Mountain and White Mountain series is not touched upon; neither is the value of lithological characters among crystalline rocks in the determination of geological equivalency discussed, beyond making an affirmation on the point, and citing the opinions of one or two authors.

The history of the discoveries and views of geologists pertaining to the so-called Taconic rocks, and the formations associated with them in the Green Mountain series, is next ably presented, the Primordial character of part of them recognized, as determined by Billings and Barande, and the later Lower Silurian character of some other portions. But with regard to the crystalline rocks, constituting his "Green Mountain Series," he says:—"Although I have, in common with most other American geologists, maintained that the crystalline rocks of the Green Mountain and White Mountain series are altered paleozoic sediments, I find, on a careful examination of the evidence, no satisfactory proof of such an age and origin, but an array of facts which appear to me incompatible with the hitherto received view, and lead me to conclude that the whole of our crystalline schists of eastern North America are not only pre-Silurian but pre-Cambrian in age"—a conclusion which all will say should be thoroughly tested by reference to stratigraphical facts before it is generally accepted.

The "Origin of Crystalline Rocks," the subject of the second part of the address, is next discussed. Facts are brought to bear upon it from various sources, many of them the result of Dr. Hunt's own careful chemical investigations. He brings out, and, of course, advocates his own peculiar views on pseudomorphism and metamorphism,—views which have been presented by him in this Journal, and need not be here repeated. He closes with a review of recent observations, and mainly his own, connected with the origin of the minerals constituting and associated with the specimens of Eozoon; and finally treats briefly of the origin of limestones and dolomites, making some great formations of them of chemical origin.

The conclusions throughout Dr. Hunt's address are open to doubts and objections; but their discussion would require as many pages as he has found necessary for presenting them.

2. *The distribution of Maritime Plants in North America a proof of Oceanic Submergence in the Champlain Period* [that following the Glacial]; by C. H. HITCHCOCK, of Hanover, N. H. —In this paper, Prof. Hitchcock has collected together the facts with regard to the distribution over North America of plants that properly belong to sea-shores, and draws from them the conclusion expressed in the title of his paper above given. The argument is an important one. But still it may be queried, considering the much greater number of shells and of other kinds of marine *animal* life that must have existed in those Champlain seas, whether their *absence* from the same regions all over the United States, beyond a height of 300 to 600 feet above tide-level in the more northeastern portions, is not better proof that the sea did *not* cover the continent in the Champlain era. It is hard to believe that there could have been thousands of miles of sea-beaches across the continent, or hundreds of thousands of square miles of sea-bottom, in an era of abundant marine life, and yet all—with the exceptions along the borders of the Atlantic, along the River (then Gulf of) St. Lawrence, and on Lake Champlain (then an arm of that Gulf)—without any traces of marine animal life.

If the depth over the continent were 5,000 feet or more, as some have supposed, there would have been sea-bottom everywhere, if no sea-beaches; and if but 500 to 1,000 feet, as others have inferred, sea-beaches would have been almost interminable as well as sea-bottoms. The latter depth (or but 600 feet in the St. Lawrence region) has been thought sufficient to turn a part of the Labrador current in full flow over the continent, thence to discharge itself by the Mississippi valley into the Mexican Gulf, and hence sufficient also to transport southward icebergs that might be in the way.

But oceanic currents, although strongest toward the sides of an ocean, where the depth is diminishing landward, are extremely feeble over ordinary off-shore soundings; and many facts prove that the waters of the continent, in the supposed case, would be but the waters of a great interior sea, having only the very feeble movement that might come from the tides setting in by the south and the northeast, so that the necessities of the iceberg theory would not be met. Icebergs and vast fields of floating ice over the interior of the continent were probably among the phenomena of the closing glacial era, during the opening Champlain period; but the waters bearing them must have been fresh waters—viz., those of the much expanded Great Lakes, and those of the flood (first appealed to in this connection by Prof. Hilgard) which proceeded from the melting continental glacier over the vast funnel-shaped Mississippi valley reaching from the Appalachians on the east to the far distant Rocky Mountains on the west.

In a geological paper on the New Haven region (Connecticut), recently published by the writer, it is stated that the Champlain beds of sand and gravel which underlie the plain about the bay, show, by the character of the stratification, that they were deposited by the inflowing tidal waves; but over a region where the Quinnipiac valley opens out upon the plain, the evidence of tidal deposition stops abruptly at a level twenty feet from the top, and these upper twenty feet nearly to the top bear unquestionable evidence of deposition by the *outflowing flooded river*. This part of the continent, therefore, was certainly not submerged in a deep or shallow ocean during the Champlain era. J. D. D.

3. *Some of the Results of the Latest Researches in the Waters of the Atlantic and Mediterranean.*—These results, as set forth in a lecture by Dr. Wm. B. Carpenter, before the Royal Institution, are briefly as follows:

(1.) The waters of the Atlantic between Falmouth and Lisbon are most salt and dense at the surface, as first observed by Forchhammer. The specific gravity ranged from 1·0269 to 1·0265, the maximum at surface, the minimum at bottom. The amount of chlorine in grams per 1000 cubic centimeters of water (determined by volumetric analysis) averaged at surface 19·94, at bottom 19·75, intermediate region 19·85. The maximum at surface was 20·19. In waters taken on the same vertical line the chlorine was at surface 20·013, at 10 to 50 fathoms 19·909, at 100 f. 19·805. This excess of saltness at surface is attributed to evaporation. But the consequent greater density is stated to be neutralized by the effects of colder temperature below.

(2.) The saltness in the Mediterranean is greatest below the surface. In the shallower parts, it is greatest at bottom. In the shallower parts of the western basin (which basin includes all west of Malta, where a submarine ridge crosses the sea, and which has over a large part a depth of 1,500 fathoms, while the eastern is near 2,000, and even 2,150 fathoms in one part), the average specific gravity and chlorine at surface were 1·0278 and 20·87; at bottom 1·0285 and 21·38. But the salinity does not increase with the depth. An average of results shows that at 200 to 400 fathoms the specific gravity and chlorine were 1·0287 and 21·53; at 400 to 800 fathoms, 1·085, 21·38; at 1,300 to 1,700 f., 1·0283, 21·21. The increase of salinity for some distance downward is attributed to a sinking of the surface layer as it becomes more dense by evaporation, an effect not apparent in the Atlantic, because the difference of salinity above and below is so slight.

(3.) The temperature of the North Atlantic waters near the margin of the basin decreases downward toward 35°, but with an abrupt falling off at 800 fathoms off the British Channel, near lat. 49. The temperature at surface being 62°·6 to 64°·0 F., it was at 75 fath., 49°·7; at 96, 51°·3; at 250, 50°·2; at 300, 49°·6; at 350, 49°·1; at 450, 47°·6; at 557, 47°·0; at 600, 45°·5; at 725, 43°·9; at 750, 42°·5; at 800, 42°·0; then a sudden fall of 3 degrees, the temperature at 862 being 39°·7; at 1,000, 38°·3; at 1,250, 37°·7.

On the coast of Spain and Portugal, average lat. 39°, the temperature at 81 fathoms was 53°·5; from which it gradually sunk to 51°·5 at 300 fath.; 50°·5 at 600; 49°·3 at 800; and then fell off abruptly to 40°·3 at 862; 39°·7 at 1,000; 39°·7 at 1,250 fathoms.

Dr. Carpenter hence observes, "It appears clear that we have in the latitude of Lisbon the same distinct separation between an *upper warm* and a *lower cold* stratum as presented itself in the channel between the Shetland and the Faroe Islands; but whilst the 'stratum of intermixture' in the latter lies between 150 and 300 fathoms, it lies in the former between 800 and 1,000 fathoms. It seems perfectly clear that the *lower* stratum must have had a Polar source; but there is no evidence that the *upper* stratum is derived from any source nearer the Equator. Its temperature, indeed, is *lower* by 4° or 5° than that of the Mediterranean in the same parallel of latitude at corresponding depths; and since the temperature of the latter may be considered as the *normal* of the latitude,—this great inland sea being virtually excluded from participation in the general oceanic circulation,—it would seem that the effect of that circulation is rather to lower than to raise the temperature of the upper stratum of this portion of the Atlantic. Its surface-temperature during the summer is decidedly *lower* than that of the Mediterranean under the same parallel; and the limitation of the *super*-heating to its most superficial layer is in entire accordance with our Mediterranean observations upon this point. As far as can be gathered from the data we at present possess, the *winter* surface-temperature of this portion of the Atlantic is scarcely, if at all, higher than that of the Mediterranean under the same parallels. Hence it seems a justifiable conclusion that neither the superficial layer, nor any portion of the upper stratum, of the Atlantic water that laves the coasts of Spain and Portugal receives any accession of heat from the extension of the Gulf-stream into its area."

(4.) The temperature of the deeper waters of the Mediterranean is very nearly uniform, being between 54° and 56°·5, and nowhere falling below 54°; and this minimum cold is reached at a depth of about 100 fathoms. In a trial giving average results for the sea, where the temperature at surface was 77°, at 5 fathoms it was 76°; at 10 f., 71°; at 20 f., 61°; at 30 f., 60°; at 40 f., 57°·3; at 50 f., 56°·7; at 100 f., 55°·5. 54° was found at a depth in one case of

790 f.; 56° in another at 1,743 f.; 55° at 1,456 and 1,508 f., these being merely local variations. Hence "*whatever the temperature was at* 100 *fathoms, that was the temperature of the whole mass of water beneath down to the greatest depth explored.*" Between Gibraltar and Sardinia the bottom temperature ranged between 54° and 55°·5, average 54°·9; toward Sicily, between 55° and 56°·5.

Dr. Carpenter concludes that "no amount of *surface*-heat has power *directly* to affect the temperature of sea-water to a greater depth than 100 fathoms, the elevation of temperature it produces below 30 fathoms being very slight; and it seems also clear that the uniform temperature of from 54° to 56°·5, encountered below the 100 fathoms' stratum, represents the *permanent temperature* of the great mass of water which occupies the Mediterranean basin. Now this mass is entirely cut off from the influence of the general oceanic circulation; the surface-inflow through the Strait of Gibraltar having no other effect than slightly to lower the general temperature at the western extremity of the basin. And the uniform permanent temperature of the mass of Mediterranean water may thus be considered as representing the mean temperature of the earth in that region, slightly raised, perhaps, by a *downward convection* of heat from the surface in the manner to be presently described. With such an allowance, it corresponds closely with the determinations of the mean temperature of the crust of the earth in Europe, made by sinking thermometers into the ground to such a depth as to seclude them from the direct influence of summer heat or winter cold, but not to bring them within the direct influence of the internal heat of the earth. The temperature of deep caves gives another set of data of the like kind, which accord very closely with the foregoing. Thus, Mr. Pengelly states that the temperature in the part of Kent's Hole, at Torquay, which is farthest from its entrance, varies but little from 52° throughout the year. There is a cave in the island of Pantellaria, lying between Sicily and the African coast, which is reputed to be of 'icy coldness;' but Lieut. Millard, of H.M.S. 'Newport,' who has lately been making a careful survey of the island, informed us that, although he felt it 'very cold' on passing into it out of a very hot sunshine, its actual temperature, taken by thermometer, was 54°. And we have also learned, on good authority, that this is the temperature of the bottom of the deepest tanks in which water is stored up in Malta, provided that these are excavated (as is very commonly the case) beneath the houses, or are in any other way secluded from the direct rays of the sun."

(5.) The waters of the Mediterranean contain matter in suspension in a very fine state of division, which it derives from its rivers, and for its western basin largely from the Rhone. The bottom-water is almost everywhere turbid, and the bottom muddy. Very little life exists over it when thus muddy, and this is attributable to the fact that life cannot exist where there is a constant deposition of this finest silt going forward, as it tends to cover the surface of the animal and prevent aeration. Thus oyster beds will not flourish in the range of river deposits. The facts correspond with those observed by Tyndal, who detected the particles in the surface-water of the Mediterranean by electric light, and attributed the deep blue color of the waters, as well as of those of Lake Geneva, to their presence.

The facts are stated to explain to geologists how non-fossiliferous argillaceous strata may have been formed in past time. Dr. Carpenter suggests, as another reason for the absence of life over the bottom of the Mediterranean, the stagnation of the waters due to an almost total absence of vertical circulation. If this last mentioned cause is a true one, it should have excluded life from the bottom, where it is rocky, as well as from the muddy part.

4. *On the Geological Age and Microscopic Structure of the Serpentine Marble or Ophite of Skye;* by Professors W. KING and T. H. ROWNEY, (Proc. Roy. Irish Acad., Jan. 1871.)—*On the Mineral Origin of the so called "Eozoon Canadense,"* by the same (Ib., Apr. 10, 1871).—In the first of these papers, the authors bring out the facts with regard to the position of the rocks, and arrive at their former conclusion that the ophite is an altered rock of the Liassic period; and further show that the eozoon-like forms of the Laurentian are paralleled in those of the skye ophite. In the second paper, Dr. Dawson's reply to the former memoir of Messrs. King and Rowney is considered in detail, and in closing, the following recapitulation is given of the points they consider as established:—

(1.) The serpentine in ophitic rocks has been shown to present appearances, which can only be explained on the view that it undergoes structural and chemical changes, causing it to pass into variously subdivided states, and etching out the resulting portions into a variety of forms—grains and plates, with lobulated or segmented surfaces—fibres and aciculi—simple and branching configurations. Crystals of malacolite, often associated with the serpentine, manifest some of these changes in a remarkable degree.

(2.) The "intermediate skeleton" of "Eozoon" (which we hold to be the calcareous matrix of the above lobulated grains, &c.) is completely paralleled in various crystalline rocks—notably marble containing grains of coccolite (Aker and Tyree), pargasite (Finland), chondrodite (New Jersey, &c).

(3.) The "chamber casts" in the acervuline variety of "Eozoon" are more or less paralleled by the grains of the mineral silicates in the pre-cited marbles.

(4.) The "chamber casts" being composed occasionally of loganite and malacolite, besides serpentine, is a fact which, instead of favoring their organic origin, as supposed, must be held as a proof of their having been produced by mineral agencies; inasmuch as these three silicates have a close pseudomorphic relationship, and may therefore replace one another in their naturally prescribed order.

(5.) Dr. Gümbel, observing rounded, cylindrical, or tuberculated grains of coccolite and pargasite in crystalline calcareous marbles, considered them to be "chamber casts," or of organic origin. We have shown that such grains often present crystalline planes, angles, and edges; a fact clearly proving that they were originally simple or compound crystals that have undergone external decretion by chemical or solvent action.

(6.) We have adduced evidences to show that the "nummuline layer" in its typical condition—that is, consisting of cylindrical aciculi, separated by interspaces filled with calcite—has orginated directly from closely packed fibres; these from chrysotile or asbestiform serpentine; this from incipiently fibrous serpentine; and the latter from the same mineral in its amorphous or structureless condition.

(7.) The "nummuline layer," in its typical condition, unmistakably occurs in cracks or fissures, both in Canadian and Connemara ophite.

(8.) The "nummuline layer" is paralleled by the fibrous coat which is occasionally present on the surface of grains of chondrodite.

(9.) We have shown that the relative position of two superposed asbestiform layers (an *upper* and an *under* "proper wall"), and the admitted fact of their component aciculi often passing continuously and without interruption from one "chamber cast" to another, to the exclusion of the "intermediate skeleton," are totally incompatible with the idea of the "nummuline layer" having resulted from pseudopodial tubulation.

(10.) The so-called "stolons," and "passages of communication exactly corresponding with those described in *Cycloclypeus*," have been shown to be tabular crystals and variously formed bodies, belonging to different minerals, wedged cross-ways or obliquely in the calcareous interspaces between the grains and plates of serpentine.

(11.) The "canal system" is composed of serpentine, or malacolite. Its typical kinds in the first of these minerals may be traced in all stages of formation out of plates, prisms, and other solids, undergoing a process of superficial decretion. Those in malacolite are made up of crystals—single, or aggregated together—that have had their planes, angles, and edges rounded off, or have become further reduced by some solvent.

(12.) The "canal system" in its remarkable branching varieties is completely paralleled by crystalline configurations in the coccolite marble of Aker, in Sweden; and in the crevices of a crystal of spinel imbedded in a calcitic matrix from Amity, New York.

(13.) The *configurations*, presumed to represent the "canal system," are *totally without any regularity* of form, of relative size, or of arrangement; and they occur independently of, and apart from, other "eozoonal features" (Amity, Boden, &c.); facts not only demonstrating them to be purely mineral products, but which strike at the root of the idea that they are of organic origin.

(14.) In answer to the argument that as all the foregoing "eozoonal features" are occasionally found together in ophite, the combination must be considered a conclusive evidence of their organic origin, we have shown, from the composition, physical characters, and circumstances of occurrence and association of their component serpentine, that they represent the structural and chemical changes which are eminently and peculiarly characteristic of this mineral. It has also been shown that the combination is paralleled to a remarkable extent in chondrodite and its calcitic matrix.

(15.) The "regular alternation of lamellæ of calcareous and siliceous minerals" (respectively representing the "intermediate skeleton," and "chamber casts") occasionally seen in ophite, and considered to be a "fundamental fact" evidencing an organic arrangement, is proved to be a *mineralogical* phenomenon by the fact that a similar alternation occurs in amphiboline-calcitic marbles and gneissose rocks.

(16.) In order to account for certain *untoward* difficulties presented by the configurations forming the "canal system," and the aciculi of the "nummuline layer"—that is, when they occur as "*solid bundles*"—or are "*closely packed*"—or "*appear to be glued together*"—Dr. Carpenter has proposed the theory that the sarcodic extensions which they are presumed to represent have been "turned into stone" (a "siliceous mineral") "by Nature's cunning" ("just as the sarcodic layer on the surface of the shell of living foraminifers is formed by the spreading out of *coalesced* bundles of the pseudopodia that have emerged from the chamber wall")—"by a process of chemical substitution *before* their destruction by ordinary decomposition." We showed this quasi-alchymical theory to be altogether unscientific.

(17.) The "siliceous mineral" (serpentine) has been analogued with those forming the variously-formed casts (in "glauconite," &c.) of recent and fossil foraminifers. We have shown that the mineral silicates of "Eozoon" have no relation whatever to the substances composing such casts.

(18.) Dr. Hunt, in order to account for the serpentine, loganite and malacolite, being the presumed in-filling substances of "Eozoon," has conceived the "novel doctrine" that such minerals were *directly* deposited in the ocean waters in which this "fossil" lived. We have gone over all his evidences and arguments without finding *one* to be substantiated.

(19.) Having investigated the alleged cases of "chambers" and "tubes" occurring "filled with calcite," and presumed to be "a conclusive answer to" our "objections," we have shown that there are the strongest grounds for removing them from the category of reliable evidences on the side of the organic doctrine. The Tudor specimen has been shown to be equally unavailable.

(20.) The occurrence of the best preserved specimens of "*Eozoon Canadense*" in rocks that are in a "*highly crystalline condition*" (Dawson) must be accepted as a fact utterly fatal to its organic origin.*

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* Dr. Carpenter, unable to defend himself against Mr. T. Mellard Reade's objection that "Eozoon" *occurs only in metamorphosed rocks* (*Nature*, No. 60),

(21.) The occurrence of "eozoonal features" *solely* in crystalline or metamorphosed rocks, belonging to the Laurentian, the Lower Silurian, and the Liassic systems—never in ordinary unaltered deposits of these and the intermediate systems—must be assumed as completely demonstrating their purely mineral origin.

The authors add to the paper the following *postscript.*

The reading of the foregoing paper was followed by a short communication from Dr. Dawson, on "two points," which it is now necessary to notice:—

One relates to some fragments of Silurian crinoids, the "cells and tubes" of which are in the state of casts composed of "amorphous hydrous silicate of alumina and ferrous oxide, with some magnesia and alkalies," also, "angular and partially rounded grains of quartzose sand"—evidently a super-aluminous example of the widely varying mixtures, known as glauconite, green-earth, &c. The case is interesting: but, never having denied the well-established fact that foraminiferal shells, corals, and other organisms occur with siliceous in-fillings of the kind—and having already determined the attempt to assimilate such substances with a certain class of minerals to be utterly unsupported by any proper evidences—we do not see the pertinency of introducing it (and some others made known last year by Dr. Carpenter) into the present discussion. Besides, it is altogether gratuitous, and inconsistent with scientific reasoning, to assume that the crinoidal in-filling "is similar to that effected by the ancient serpentine of the Laurentian" (Dawson); or, that it is "allied in the mode of its formation to the serpentine, pyroxene, and other minerals which have injected Eozoon" (T. Sterry Hunt).

The other relates to our statement of the occurrence of an essential "eozoonal feature" in connexion with a crystal of spinel, from Amity. We now learn that Dr. Dawson has had under examination specimens of spineliferous rock from the latter place:—and, notwithstanding his having pronounced the case as "*so unlikely*," the result is, that the specimens have been found to "contain in spots, remains of casts of canals similar to those of *Eozoon Canadense.*" As to the inference that the specimens "are portions of a bedded rock, and not a vein stone"—without taking into consideration that it is suppositional, and based on an examination of specimens preserved *in collections*—it cannot set aside the plain fact, that in our specimen arborescent configurations—formed of groups of decreted crystals of malacolite, and identical

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takes refuge under the *ad captandum* argument, that its "calcareous lamellæ" ("intermediate skeleton") "show less departure from the shelly texture than do the great majority of undoubted shells, corals, &c., contained in the least altered rocks of any geological period" (*Nature*, No. 62); forgetting that, as the substance of such fossils has undergone so much change, the fact demands a vast amount of metamorphism to convert the rocks containing them—"least altered" as they may be—into the "highly crystalline condition" of "eozoonal" ophite. But Dr. Carpenter seems to misunderstand the objection altogether; as it is not based so much on the mineral structure of the "eozoonal features," as on the fact that they occur best preserved in "highly crystalline" or metamorphosed rocks.—K. & R.

with perfect and the finest examples of what are presumed to be "casts of the canal system"—are present in calcite, occupying the crevices of a large crystal of spinel. The fact of itself conclusively settles their purely mineral origin.

5. *On the Oil-bearing Rocks of Ohio and West Virginia;* by A. J. Warner. (Communicated.)—In an article on the "Oil-bearing Limestones of Chicago," in the June number of this Journal, by Prof. T. Sterry Hunt, this author remarks that "much of the petroleum of Pennsylvania, Ohio, and the adjacent regions, is indigenous to certain sandstones in the Devonian and Carboniferous rocks."

It is now well ascertained that the heavier lubricating oils, produced along the well known uplift in West Virginia, are found in the crevices of the two lower members of the Carboniferous sandstones, namely, the conglomerate proper, and the next overlying sandstone stratum, the two being separated by from seventy to one hundred feet of shales. The light petroleum produced in this same district is principally found about three hundred and fifty feet below the Coal-measure conglomerate, or in the Upper Devonian shales. In the region of Sand Hill, where the uplift reaches its maximum elevation, the base of the conglomerate is brought to within about three hundred feet of the surface. The Subcarboniferous limestone, as well as all true representatives of the Vespertine and Umbral of Prof. Rogers, seem here to be wanting. Nor at the depth at present attained by boring is there any well-defined or true sandstone, the light oil being found rather in a coarse dark-arenaceous shale.

In the Cow Run oil district in Ohio, which lies northward from the Virginia district, and along a low but quite sharp anticlinal belt—whether strictly an extension of the West Virginia anticlinal or not, seems as yet unascertained—the oil, which is here of light gravity, is found principally in the sandstone stratum, which forms a part of the hills in the West Virginia district, and is doubtless the Mahoning sand of the Pennsylvania survey. In this district the conglomerate is passed through at a depth of about twelve hundred feet. While in Virginia the crevices of the conglomerate were filled with oil, the lighter portion of which had escaped by evaporation, in Ohio in the same rock but little oil is found, while strong salt water fills most of the crevices.

Now, while these several sand rocks, where they come to the surface, contain Calamites, Stigmaria, and other fossil plants of the lower Coal-measures, they contain nothing from which petroleum could possibly have been derived.

Again, if the oil originates in the sandstones where it is found, why is it limited strictly to these sharp anticlinal belts? The evidence seems abundant, that, at least in the districts under consideration, the oil comes from lower strata, but whether from the nearer Genesee and Marcellus slates, or the deeper Silurian limestones, may, perhaps, be yet a question; but facts which would require too much space to ask for here, favor the view of the nearer source in the bituminous shales.

Marietta, Ohio, July 12.

6. *Notes on some points in the Mineralogy and Geology of Utah;* by W. P. BLAKE. (From a letter to Prof. B. SILLIMAN, dated Salt Lake City, July 27, 1871.)—I left New Haven hurriedly to reach the Emma Mine and examine it. It is a remarkable mine. Within a little more than a year it has yielded ore worth over $2,000,000, and this without any special outlay. It is a great mass of soft earthy-looking ore, the result of the decomposition of argentiferous galena. It is dug out with shovels and picks, sacked, and sent to Liverpool, where it sells for about $175 per ton. The mass is between strata of limestone, the middle members of a series of strata over a mile thick. The lower members are slate and quartzite, and rest upon the immense masses of syenitic granite which form the picturesque Alpine-like peaks of the Wahsatch. These strata are all much uplifted and contorted, some of the harder beds surging up into peaks at least 11,000 feet above tide. The mine is at an elevation of 8,500 to 9,000 feet. At the head of the cañon upon the side of which it is situated, there is a fine exposure of syenitic granite for about a mile, with rounded polished backs—*roches moutonnées*—probably 9,000 above tide. These rocks give conclusive evidence of the former existence there of a large glacier. Much of the polish upon the surface has been removed by the action of the weather. The patches that remain are dark brown in color, while the syenite is light gray, and they show the same peculiar scale-like crusts seen on the partly weathered glaciated surfaces above the Yosemite.

In addition to the carbonate of lead, the mingled oxides of lead and antimony, etc., found generally in the decomposed lead ores of the limestone formation, I have seen some peculiar and interesting species from other parts of the Territory. *Sal Ammoniac* is shown here in large masses from the southern part of Utah. It is remarkably pure and free from iron. *Trona* is now about to be largely produced from the shallow lake on the Sweetwater, near Independence Rock. *Cinnabar* occurs in Camp Floyd District. *Bismuthinite* is likely to be produced in considerable quantity from a vein in syenite recently opened by Messrs. C. F. and J. B. Meader in the southern part of the Territory. It is associated with pyrites, brown dodecahedral garnets, and considerable hornblende.

7. *Note on Coal-measure Fucoids;* by G. C. BROADHEAD.—(Communication dated Pleasant Hill, Mo., July 14th, 1871.)

I have been interested in two communications in the June and July numbers of the Journal regarding *Caulerpites* and coal-plants. In Owen's second Report on the Geology of Arkansas, p. 302, Lesquereux reports the occurrence of *Fucoides Cauda-galli* in a sandstone of Crawford Co., Arkansas, in the neighborhood of the coal-fields. Considering it Devonian, he is puzzled at its occurrence there, and suggests the possibility that it has "a much wider range of distribution than had till now been supposed." He adds that "in some places, along the margin of the eastern coal-basin of Kentucky, the Conglomerate is sometimes underlaid by this formation of the *Fucoides Cauda-galli.*" I think that further investigation would show this Crawford Co. sandstone to belong to the Coal-measures.

I observed the *Caulerpites* first, about the year 1859, in Randolph Co., Mo., occurring in hard sandstone and sandy limestone of the Coal-measures, and not very remote from the base of the Lower series: it was there about five feet below a four-foot bed of coal. I have observed traces of the same, here at Pleasant Hill, in Upper Coal-measure sandstone and sandy limestone, and at one other locality in Missouri—I think probably in Lafayette Co. In 1868, I discovered *Caulerpites* in a shaly sandstone of the Upper Coal-measures, in Montgomery Co., Illinois, above the horizon of coal No. 13.

8. *On Carboniferous and Subcarboniferous Fossils in Monongalia Co., West Virginia;* by F. B. Meek (Report Regents of University, W. Virginia).—Mr. Meek describes in this paper some new species, viz: *Macrodon obsoletus*, of the Lower Coal-measures, *Nucula anodontoides*, *Yoldia Stevensoni* and *Y. Carbonaria* of the Coal-measures, and *Phillipsia Stevensoni*, from the Chester group of the Subcarboniferous. From a survey of the species collected, he concludes that the Chester group (of the Illinois Reports) is represented in Western Virginia by at least six Illinois species, and along with ten or a dozen other species which he could not identify because of the imperfect state of the specimens. The beds also contain *Hemipronites crassus*, a Coal-measure species, and a *Cyrtoceras* and *Bellerophon*, closely like species of the Coal-measures. He observes that Monongalia County is the farthest point eastward at which the Chester group, or indeed any other of the divisions of the Subcarboniferous limestones of the West, has yet been recognized. The species from the lower Coal-measures are mostly the same that occur in the Coal series of Indiana, Illinois, Missouri, Kansas, Nebraska, etc., though few of them have before been found so far eastward. In some of the States mentioned, nearly all of the species range through the whole of the Coal-measures, showing, as Mr. Meek remarks, that species lived on through a great length of time, and consequently that the climatic and other physical conditions of the era must have remained remarkably uniform.

9. *On the Stratigraphic Relation of the Orders of Reptilia;* by Prof. Edward D. Cope.[*]—The stratigraphic relation of the orders of Reptiles is shown in the following table:—

Present—Rhynchocephalia; Crocodilia; Testudinata; Lacertilia; Ophidia.
Pliocene—Crocodilia; Testudinata; Lacertilia; Ophidia.
Miocene—Crocodilia; Testudinata; Lacertilia; Ophidia.
Eocene—Crocodilia; Testudinata; Lacertilia; Ophidia.
Cretaceous—Ornithosauria; Dinosauria; Crocodilia; Sauropterygia; Testudinata; Lacertilia; Pythonomorpha.

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[*] From a Memoir on the Homologies of some of the Cranial bones of the Reptilia and the Systematic Arrangement of the Class, in the Proc. Am. Acad. (Boston), xix, 194. On the preceding page of the memoir the author argues that the supposed *Lacertilia* of the Permian are all *Rhynchocephalia*.

Jurassic—Ornithosauria; Dinosauria; Ichthyopterygia; Crocodilia; Sauropterygia; Testudinata; Lacertilia.
Triassic—Dinosauria; Anomodontia; Rhynchocephalia; Ichthyopterygia; Crocodilia; Sauropterygia; ? Testudinata. ?
Permian— ? Rhynchocephalia.

It will be observed, by this table, that the most specialized Reptilian order, the Ophidia, appeared last in time in the Eocene period; and that those which constitute the line of connection with the generalized reptiles appeared earlier as they approached the latter,—the Pythonomorpha in Cretaceous, and Lacertilia in Jurassic times. The Reptilian groups most specialized in bird characters (Ornithosauria and Dinosauria) appear on the other hand very early; the first and most mammalian also,—the latter of the two, in Jurassic beds. The Trias gives us in the Anomodontia and Ichthyopterygia the two most generalized and lowest orders; while their contemporary, the Rhynchocephalia, almost as much generalized in Reptilian features proper, was already represented in the Trias. Strangely enough this order yet exists in the living Sphenodon of New Zealand. The Crocodilia, rather specialized in bird characters, accompanies the last in this wonderful persistency, beginning also in the Trias.

The inquiry as to the truth of the proposition that the more ancient types of animals are more generalized, and therefore more embryonic in the characters of a special nature* which characterized groups later introduced, is answered in a very imperfect way in the affirmative. It is like the shadow of a truth whose substance will shortly come before us. But when we come to compare the subdivisions of the orders themselves with each other, and with those of other orders, as we pass backward in time, the weight of the affirmative answer to the above proposition is greatly increased. The oldest Ophidia are boæform, therefore approaching Lacertilia and Pythonomorpha. The oldest Tortoises have generally the most incomplete carapace and plastron; among them the Psephoderma allied to Sphargis, without carapace, and thus the most lizard-like of the order. The Lacertilia of European Jurassic strata are, some of them at least, acrodont, apparently Pachyglossa (*e. g.*, Acrosaurus), and, as such, nearer the Rhynchocephalia, which preceded them in time. The position of Homorosaurus and Piocormus is not determinable, as the dentition cannot be understood from the descriptions and figures of Wagner. The form of the mesosternum of the former refers it to either the Pachyglossa or Iguana, as I understand those groups. It may be assumed that since the order Lacertilia has diverged from the line of other Reptilia, while it took on in its special peculiarities, it lost in the features characterizing the main series with a higher tendency or terminus, thus *retrograding* in one sense. This is seen in the shortened sacrum, pleurodont dentition, etc.

The Crocodilia of the Jurassic do not possess the ball-and-socket-jointed vertebræ of the recent genera, and exhibit the plane articular faces of all the Jurassic and Triassic Reptilia. Their basicranial region is also plane like that of other orders, instead of vertical as in the recent forms. The Triassic Crocodiles are still more generalized. Their ribs are extended to the pelvis, as in Dinosauria and Anomodontia: there are often three sacral vertebræ, an approach to the long sacrum of the same orders. The femur, with third trochanter, is an approach to that of the Dinosauria; and finally the position of the nostrils near the orbits (Belodon) is a Sauropterygian feature. In the Sauropterygia the shortened vertebral column, and long muzzle (Pistosaurus) in the oldest types (Triassic), are approximations to the Crocodilia. The Dinosauria display an increasingly Crocodilian character as we pass into the Triassic period. The femur (Palæosaurus), Megadactylus) loses the bird-like head, and assumes the ill-defined convexity of the Crocodiles; the tibia (Plateosaurus) loses the bird-like "spine," or crest. The illium is shorter (Palæosaurus). Every student of the subject knows how much more difficult is the separation of the bones of Sauropterygia, Crocodilia, Anomodontia. and Dinosauria, of the Trias, than those of the Cretaceous. There are types allied to the Rhynchocephalia, whose systematic position is doubtful, owing to the generalized character of the parts we possess. Thus the Rhynchosaurus of the Trias of England is allied to that order, and to the Anomodontia. The Rhopalodon of the Permian has a large canine tooth, like the single one possessed by the Anomodontia; but with others associated, like those of the Rhynchocephalia. The Triassic Sauropterygia and Rhynchocephalia also agree in the anterior production of the pterygoid bones between the palatines to the vomer. Compare, for this point, Hyperodapedon and Nothosaurus.

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* The identity of these two propositions has not always been noticed by authors.

We learn from such considerations as the above, and similar ones derived from the study of the Mammalia, that the successional relation of the faunæ of the periods in geologic time is more strikingly exhibited by the subordinate contents of the orders than by the orders themselves, in relation to each other. From this we decide that we must look for the origin of the orders in periods prior to those in which we now know them, if, as some suppose, they originated in still more generalized types. This accords with Huxley's view of the period of origin of the mammalian orders.

It must also be remembered that the above deduction as to geological distribution is precisely that of geographical distribution; *i. e.*, that the homologous groups of different continents are not orders, but subordinate divisions of orders, the orders being universally distributed. This coincidence is remarkable, and justifies the view I have taken of the origin of higher types on the basis of retardation and acceleration, and of the nature of synchronism.*

10. *Endurance of Heat by Infusoria;* by F. C. Calvert. (Am. Mag. N. H., IV, viii, 129).—A solution of sugar in which infusoria had appeared, when subjected to 212° F., still contained 4 or 5 small black Vibrios quite active, and 2 or 3 energetic ordinary

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* Origin of Genera, 1868; Hypothesis of Evolution, 1870.

Vibrios. The same, heated to 300° F., was found to contain ordinary Vibrios and 1 or 2 black Vibrios. At 400° F. the sugar was mostly decomposed and all life had disappeared.

An infusion of hay was similarly treated; after heating to 212° F. there were present a few small black Vibrios; and even after heating to 300° F., though a less number. None was found after heating to 400°. 212° F. destroyed all the fungous matter that was before present in the tubes.

The life in an infusion of gelatine was slightly decreased at 100° F., very largely at 212° F. and had wholly disappeared at 300° F.

The infusoria in putrid meat fluid were but slightly affected at 100° F.; at 212° F. a small part remained alive but inactive, the liquor becoming turbid and coagulated; at 300° F., a few Vibrios were alive, the small black ones the most numerous; at 400° F. all life had disappeared.

In each case the infusions were examined 24 days after the heating. The results show that infusorial vegetable life of some kinds may survive a temperature of even 300° F., but not of 400° F.

At 15° F. the infusoria became languid, but with an increase of temperature again they were as active as ever.

11. *Metschnikoff on the affinities of Crinoids.*—Metschnikoff, to whom we owe so many valuable embryological investigations, has published preliminary notices* of the early stages of Comatula which are of the utmost importance, as they throw an entirely new light on the affinities of the Crinoids. Thoroughly familiar with the Pluteus of Holothurians, Echini, Starfishes and Ophiurans, he commenced the investigation of their earlier stages with the determination of tracing the presence of the peculiar water-system of the larvæ of the other orders of Echinoderms, what had been previously written by Busch, Allman and Thomson, on the early stages of Comatula, giving no data whatever bearing upon the subject.

To his surprise he found no such water-system, nor could he trace anything in any way homologous to it; he also discovered that what constitutes the water-system of adult Crinoids, which has always been homologised with the water-system of other Echinoderms is developed in a totally different manner. In the fre swimming Comatula larva the bag-like digestive sac is the only organ developed, it becomes the digestive cavity of the adu after the larva attaches itself to the ground. He noticed the tentacles as diverticula of the digestive sac in the interior of th larva; these subsequently force their way through to the exterior at the time when the digestive bag has become further differen tiated, and is provided with a mouth opening in the center of th oval disk, and an anus opening not far from it on the side the calyx. There is formed at this stage a large cavity whic divides into two parts; the upper part, uniting the hollo tentacles at their base, forms the so-called circular canal, while below it, and connecting with it, we have a large cavity forming the perivisceral cavity, a mode of development of the circular ring and of the perivisceral cavity totally unlike that observed in Ophiurans, Starfishes, Echini and Holothurians.

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* Bulletin Acad. St. Petersburg, xv, p. 508, February, 1871.

Metschnikoff compares the mode of development of the upper and lower cavity to analogous processes in the embryonic growth of Alcyonella and other Bryozoa; he traces a striking similarity in the structure and position of the digestive organs and tentacles with similar organs of Bryozoa. However that may be, he has shown conclusively that the larva of Comatula has apparently nothing in common with other Echinoderm larvæ; but we must wait for his figures on this intricate subject before we can decide if the position he assigns to Crinoids is true to nature. A. AG.

12. *Chinese Botany.*—We have received, through the kind attention of the author, a curious pamphlet, of 50 pages, *On the Study and Value of Chinese Botanical Works, with Notes on the History of Plants and Geographical Botany from Chinese Sources;* by E. BRETSCHNEIDER, M.D., Physician of the Russian Legation at Peking. Illustrated with 8 Chinese wood-cuts. Printed at Foochow. The preface bears the date of Dec. 17, 1870. In it the author declares that he is "neither a Sinologue nor a Botanist;" his "knowledge in Chinese as well as in botany being very limited." But his enquiries on the spot under advantageous conditions, and the use he has made of "the splendid library of the Russian Ecclesiastical Mission at Peking, where are to be found not only all Chinese works of importance, but also most European books relating to China," have not been fruitless. The pamphlet, not to speak of critical matters, is full of interesting information concerning esculent, medicinal, and other economical plants, natives of China or of early introduction, and the question of nativity or the source of introduction is treated of by the aid of Chinese documents, some of them of high antiquity. Cotton appears to have been of comparatively recent introduction, having reached China in the 9th or 10th century, from Central Asia and Cochin China. Contrary to some authorities, "it can be proved from Chinese sources that Maize and Tobacco are not indigenous in China." But the *Batatas*, or Sweet Potato, held to be of American origin, "was described in Chinese books a long time before the discovery of America, i. e., in the third or fourth century." Sugarcane did not pass from China to India, but the reverse, and as early as the second century B. C., although it was several centuries later that a native of India taught the Chinese to make crystallized sugar, or "stone honey." A. G.

13. *Plants killed by Frost: do they die in Freezing or in Thawing?*—That in certain cases plants die in freezing, is shown by Prof. Gœppert, of Breslau, in a very satisfactory way, in an article in a recent number of *Bot. Zeitung.* The flowers of certain Orchids, notably the milk-white blossoms of *Calanthe veratrifolia*, produce indigo; but only upon a chemical reaction, which

takes effect upon the death of the parts. When crushed, or the cells in any way destroyed as to vitality, they turn blue immediately. Now, upon exposure to cold, the flowers turn blue at once upon freezing, showing that life then departed. *Phaius grandiflores* and other species of that genus are said to show the same thing.

A. G.

III. ASTRONOMY.

1. *Scintillation of the Stars.*—Prof. L. RESPIGHI has published an extended and very interesting paper upon this subject, it being an extract from the proceedings of the Accademia Pontificia de Nuovi Lincei, at the session held Febr. 14, 1869. It gives the results of a great number of observations made with the spectroscope upon stars of different magnitudes, and with every variety of circumstance as to elevation, azimuth, atmospheric conditions, and the like. The first portion of the paper is a *resumé* of an earlier one giving the results of a series of observations made previously to May 1868. The conclusions arrived at, although incomplete, were so important, that Prof. Respighi made a more extended series of over 700 observations, which were continued from October, 1868, to February, 1869. The instrument employed was an equatorial by Merz, with an aperture of 4½ inches, and provided with a direct-vision prism by Hoffmann, with a cylindrical lens between the prism and the ocular.

When the telescope was directed toward a star near the horizon, the spectrum of the star with its characteristic lines was seen, and in addition to these, broad bands, usually dark, very rarely bright, which slowly traversed the spectrum from one end to the other, passing from the violet to the red, when the star was in the east, and in the opposite direction when it was in the west. The characteristic phenomena, as summed up by Prof. Respighi, are as follows.

(1.) In normal atmospheric conditions, the motion of the bands is from the red to the violet for stars in the west, and from the violet to the red for stars in the east.

(2.) Near the meridian, whether north or south, the motion generally oscillates from one color to the other, and sometimes the bands appear stationary, or traverse only a portion of the spectrum.

(3.) The motion of the bands is more regular and less rapid near the horizon, while at greater altitudes it is less regular and more rapid.

(4.) When the instrument is so placed that the spectrum is vertical, the motion of the bands is the same as when it is horizontal, but the bands are less definite, and nearly transversal, up to an altitude of 30°; while for greater altitudes they become successively more indistinct, changing into longitudinal bands, and sometimes into mere moving masses either bright or obscure, and not rarely resulting in mere changes of brightness.

(5.) The bright bands are more rare and less regular than the dark ones, and occur only near the horizon.

(6.) Not unfrequently, in the case of stars of low altitude, besides the bands which are regular, there occur other series of bands less regular and more inclined, and sometimes also longitudinal.

(7.) Under normal atmospheric conditions, neighboring stars all present the same phenomena.

(8.) Under abnormal conditions of the atmosphere, the bands are more feeble and more irregular in form and movement.

(9.) When high winds prevail, the bands are very faint and indistinct, and sometimes appear as mere changes of brightness in the spectrum, even when the stars are near the horizon, and very bright.

(10.) When the images of the stars are very diffuse, the bands are most feeble and indistinct.

(11.) When the bands are regular in form and movement, there is generally good weather; and it would appear in general that regularity in the phenomena of scintillation is a reliable basis for predicting the continuance of fair weather.

(12.) The phenomena of scintillation are most distinctly marked on evenings of greatest atmospheric humidity.

Prof. Respighi then discusses the cause of the scintillation as indicated by the phenomena observed. The regularity and constancy, both in direction and velocity, of the motion of the bands with respect to the meridian, namely, from red to violet for stars in the west, and from violet to red for those in the east, shows that it cannot be attributed to ascending or descending movements of the atmospheric masses, but must be due to some more general cause; and he concludes that this cause is the rotation of the earth, by which the luminous rays are carried through atmospheric strata of varying density.

For, in traversing the air, the path of the least refrangible rays would present the least deviation from a straight line, and that of the most refrangible the greatest. Of the rays which pass into the instrument or the eye therefore, the violet must enter the atmosphere at a more elevated point than the red rays. Hence the cone of rays if traced backward from the eye toward the star would be spread out into a vertical spectrum, with the most refrangible rays uppermost, and the others lying successively lower in their order. The curvature of the rays in passing through the air, as affecting the different rays in the same direction, may be neglected. Prof. Respighi finds by calculation, that for a star near the horizon, the breadth of this spectrum at a distance of 90 kilometers from the observer would be not less than 10 meters, and near the limits of the atmosphere it must be several times as great.

Now the rotation of the earth carries the luminous cone onward, causing the rays to traverse successively different portions of the atmosphere. If there are heterogeneous strata in the latter from condensation or rarefaction, these would act successively upon the different colors of the cone in their order. Toward the west, the motion of the air, relatively to the cone, is upward, and hence the red rays of the latter are encountered by it first. In the east the phenomena occur in the reverse order, the violet rays being the first to be affected.

Now the dispersion of the rays, for a star near the horizon, corresponds to a very small angle at the eye of the observer, and a very slight increase or decrease in the density of a portion of the air may cause a considerable deflection of a ray from its normal path.

If then the star observed is in the east, the mass of air will meet the violet end of the spectrum first, and as its refracting power is changed with its density, the violet rays will be deflected. They will thus be thrown out of the spectrum, causing a dark band, which will advance through the other colors, as the mass of air travels through the other portions of the cone of rays. If the star is toward the west, the mass of air will meet the red end of the spectrum first, and the dark band will pass from the red to the violet. At or near the north and south points, as the atmospheric motions would in general be transverse to the spectrum formed in the air, the bands, if formed at all would move in either direction indifferently, and present great irregularities.

As the elevation of the star increases, the length of the atmospheric spectrum becomes less and less, as the incidence of the rays becomes more nearly normal, and the bands traverse it with correspondingly greater velocity. Above 40° of altitude, Prof. Respighi has found that the cone of rays differs so little from a cylinder that the effects above described are scarcely perceptible.

Again, taking the divergence of the rays at the eye of the observer as about 11″, which is probably near the truth, as the angle described by the earth in one second is 15″, the time occupied by a dark band in passing the whole length of the spectrum would be somewhat less than one second, and in the observations the time was found to be not far from this.

Considering the complete agreement of these deductions with the phenomena observed, Prof. Respighi concludes that the cause of the scintillation is to be found in the actual subtraction of a portion of the rays by the unequal refraction of the masses of air through which they are caused to pass by the rotation of the earth, and he is thus led to reject both the explanation of Arago, according to which it is due to interference, and that of Montigny who ascribed it to the total reflection of a portion of the rays by strata of air unequally heated.

In the case of the planets, owing to the breadth of their disks, the spectra are superposed, and the phenomena are in general not distinctly seen, as they produce ordinarily simple changes of brightness, or mere irregular oscillatory movements of the images. In observations upon the brighter planets, however, especially Venus, when near the horizon, Prof. Respighi has occasionally, under favorable circumstances, recognized the same phenomena as are displayed by the fixed stars. A. W. W.

2. *On the recent Solar Eclipse;* by J. NORMAN LOCKYER.—Mr. Lockyer closes an interesting lecture on the Solar Eclipse, delivered before the Royal Institution, on March 17th, as follows:

I will proceed now, if you will allow me, to some of the general results obtained during the last eclipse.

I think that, although the work has been very unfortunately interrupted, still the result has been most satisfactory. By putting together observations here and observations there, I consider that our knowledge of the sun is enormously greater than it was a few months ago. For instance, we are enabled to understand the long-neglected observation of Rayet, and the equally long-neglected observation of Pogson; and we know that outside the hydrogen there is, in all probability, a new element existing in a state of almost infinite tenuity. And we are sure of the existence of cool hydrogen above the hot hydrogen, a fact which seemed to be negatived by the eclipse of 1869.

I think, if we had merely determined that there was this cool hydrogen, all our labor would not have been in vain, as it shows the rapid reduction of temperature; but there is more behind. I told you that M. Mädler, in summing up the observations made up to 1860, came to the conclusion that part of the corona was certainly solar, and that whether the outer portions were or were not solar, was a matter of doubt. I do not say that we have settled that absolutely, but we have firm evidence that *some* of the light of the corona is due to reflexion between the earth and the moon. The outer corona was observed to have a rosy tinge over the prominences, and the spectrum of the prominences was detected many minutes above them, as well as on the dark moon. It could not have got this color *at the sun*, for its intrinsic color is green, and the red light of the hydrogen supplied at the sun is abolished altogether, is absorbed, and can only reach the corona *at the sun*, so to speak, as dark light.

It is a great fact that we are sure, as far as observation can make us sure, that there is a glare around the hydrogen which gives us the spectrum of hot hydrogen on the corona, *where we know that hot hydrogen does not exist.* Assume the hot hydrogen which gives us the red light to be only two minutes high, the spectroscope has picked it up eight minutes from the sun! The region of cool hydrogen is exaggerated in the same way. We get it where there is no indication of the cool hydrogen existing. And then, with regard to the element which gives us the line of the green, we get that twenty minutes or twenty-five minutes away from the sun. Well, no man who knows anything about the matter will affirm that it is certain that the element exists at that distance from the sun.

Therefore I think we have absolutely established the fact that as the sun—the uneclipsed sun—gives us a glare around it, so each layer of the chromosphere gives us a glare around it. That is exactly what was to be expected, and that it is true is proved by the observation—a most important observation made in Spain—

that the air, the cloud, ever between us and the dark moon, gives us the same spectrum that we get from the prominences themselves.

Given, however, the layers and elements in the chromosphere extended as far as you will, and apparently increased or not by reflexion *not at the sun*, we have still to account for rays, rifts, and the like. If anyone will explain either Mr. Brother's photograph or Mr. Gilman's picture of the eclipse of 1869, containing those dark bands starting from the moon and fading away into space, and the bright variously-colored rays between them, on any solar theory, he will render great service to science. But in the meantime I must fall back upon M. Mädler's opinion of 1860, with the addition to it that I have stated that we have found, at all events, *that some* of the doubtful light is now solar; we have turned the opinion into a fact.

Bear in mind that close to the sun you have a white layer composed of vapors of many substances, including all the outer ones; outside this is a yellow region; above that a region of hydrogen, incandescent and red at the base, cooler, and therefore blue, higher up, the red and blue commingling and giving us violet; and then another element thinning out and giving us green. Take these colors in connection with those which are thrown on our landscapes or on the sea during eclipses, each region being lighted up in turns with varying, more or less monochromatic, light, and that light of the very color composing the various layers, each layer being, as I have shown, so much brighter than the outer ones that its light predominates over them. Is it too much to suggest to those who may be anxious to attempt to elucidate this subject, that probably if they would consider all the conditions of the problem presented by that great screen, the moon, allowing each of these layers by turn to throw its light earthward, the inequalities of the edge of the *globular* moon allowing here light to pass from a richer region, here stopping light from even the dimmer ones, they would be able to explain the rays, their colors, variations, apparent twistings, and change of side? I do not hesitate to ask this question, because it is a difficult one to answer, since the whole question is one of enormous difficulty. But difficult though it be, I trust I have shown you that we are on the right track, and that in spite of our bad weather, the observations made by the English and American Government Eclipse Expedition of 1870 have largely increased our knowledge.

With increase of knowledge generally comes a necessity for changing the nomenclature belonging to a time when it was imperfect. The researches to which I have drawn your attention form no exception to this rule. A few years ago our science was satisfied with the terms prominences, sierra, and corona, to represent the phenomena I have brought before you, the nature of both being absolutely unknown, as is indicated by the fact that the term *sierra* was employed, and aptly so, when it was imagined the prominences might be solar mountains! We now know many of the constituent materials of these strange things; we know that we are dealing with the exterior portion of the solar atmosphere, and a large knowledge of solar meteorology is already acquired, which shows us the whole mechanism of these prominences. But we also know that part of the corona is not at the sun at all. Hence the terms *leucosphere* and *halo* have been suggested to designate in the one case the regions where the general radiation, owing to a reduced pressure and temperature, is no longer subordinate to the selective radiation, and in the other, that part of the corona which is non-solar. Neither of these terms is apt, nor is either necessary. All purposes will be served if the term corona be retained as a name for the exterior region, including the rays, rifts, and the like, about which doubt still exists, though it is now *proved* that some part is *non-solar*, while for the undoubted solar portion the term Chromosphere—the bright-line region—as it was defined in this theatre now two years ago, exactly expresses its characteristic features, and differentiates it from the photosphere and the associated portion of the solar atmosphere.

Here my discourse would end, if it were not incumbent on me to state how grateful I feel to Her Majesty's Government for giving us the opportunity of going to the eclipse; to place on record the pleasure we all felt in being so closely associated in our work with the distinguished American astronomers who from first to last aided us greatly; and to express our gratitude to all sorts of new friends whom we found wherever we went, and who welcomed us as if they had know us from our childhood.

3. *Shooting Stars of August 10th–11th.*—At Sherburne, N. Y., a party of six persons watched for the August meteors on the night of the 10th–11th of the month. Between $11^h\ 40^m$ and 12^h, *forty-eight* were seen. In the next hour *one hundred and forty-three* were counted, and in the first eighteen minutes of the next hour, *thirty-two.* By this time the moon was sensibly diminishing the numbers seen, and the party broke up.

The latitude of the radiant was one and one-half degrees less than that of the nebula in Perseus. Its length was at least two degrees, extending from a point 2° or 3° to the left of that star to one 8° or 10° to the right. A large part of the tracks near the radiant could, however, be regarded as diverging from the portion to the left of *Eta.* Nearly or quite seven-eighths of the meteors were judged to be conformable to the above line as a radiant.

H. A. N.

4. *On a Meteor seen at Wilmington, N. C., July* 19; by Capt. E. S. Martin.—On Wednesday night, July 19th, between 8 and 9 o'clock, we were very much startled by a blaze of light, followed by a hissing noise like fire roaring. Our first thought was that the house was on fire, but, in a second, a large ball of fire came rolling through the air, immediately over the house, from the south toward the north, and broke in the northern heavens, throwing off three large stars of crimson fire. Almost a minute after, there came a loud report, as of a cannon, only followed by a roll too long for a gun and not quite long enough for thunder.

IV. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Deep Sea Dredging, under the direction of the Coast Survey.*—The U. S. Coast Survey Steamer F. R. Hassler, commander P. C. Johnson, U. S. N., now approaching completion at Wilmington, Del., will be dispatched as soon as ready to the coast of California for the survey for which she is designed.

Prof. Peirce, Superintendent of the Coast Survey, to make this long voyage by way of the Straits of Magellan as profitable as possible to science, has offered to Prof. Agassiz the direction of a scientific party to sail in her, and pursue during the voyage deep sea researches and investigations in natural history at the different points of stoppage. The party will consist of Prof. Agassiz as director (accompanied by Mrs. Agassiz), Ex-President Hill of Harvard College as physicist, Assist. L. F. Pourtales of the Coast Survey in charge of deep sea dredgings, Dr. Steindachner as icthyologist, Mr. Blake as draughtsman. Some of the officers of the ship have also qualified themselves to assist in various researches. The points at which the steamer will probably stop will be Bermuda, Trinidad, Rio Janeiro, Montevideo, the Falkland Islands, the Straits of Magellan, Juan Fernandez, the Gallapagos.

The ship is fitted out with a special view to deep sea soundings and dredgings, and will probably be ready for sea in the latter part of September.

2. *International Congress of Prehistoric Anthropology.*—The annual meeting of this Congress, instituted by the Italian men of science, will open at Bologna on the 1st of October next, and continue eight days. The payment of twelve francs, which may be sent to Professor Capellino at Bologna, will entitle any one to a card of membership and to all its publications. The special questions before the meeting are:

(1.) The age of Stone in Italy.

(2.) The caverns on the borders of the Mediterranean, and particularly those of Tuscany, compared with those of southern France.

(3.) The lake-dwellings of northern Italy.

(4.) Analogies between the "Terramarres" and the Kjœkkenmœdding.

(5.) Chronology of the first substitution of bronze for iron.

(6.) Craniological questions with reference to the several races which have peopled the different parts of Italy.—*Les Mondes*, xxiv, 672.

3. *Prof. Marsh's Rocky Mountain Expedition.*—A letter to one of the editors from Prof. Marsh, dated Fort Wallace, Kansas, July 25th, 1871, states that he has just returned from his preliminary trip, among the Saurians, and has in his large collections, obtained in Kansas during the last fortnight, some very interesting things, including various portions of the hind limbs of the Mosasaurs, and some more remains of the Pterodactyl found last season.

By the latest information from the party, they were at Salt Lake City, bound westward.

4. *British Association.*—The meeting for the current year at Edinburgh commenced on the 2nd of August. Sir William Thomson, the President, delivered his inaugural address in the Music Hall. The Emperor of Brazil occupied a chair on the President's right hand. The present was the third meeting at Edinburgh during the 40 years of the existence of the association.

The report of the treasurer shows that at the Liverpool meeting (1870) £852 were taken in annual subscriptions, £1,103 from associate's tickets, and £910 from ladies' tickets. The whole income of the year was a little over £5,239, or more than twenty-six thousand dollars.

5. *American Association.*—The meeting was opened at Indianapolis on the 16th of August. The address of Prof. T. Sterry Hunt, the retiring president, was delivered to a large audience in the evening. Besides other business of the morning session, Professor J. E. Hilgard, of the U. S. Coast Survey, chairman of a special committee appointed with reference to establishing an observatory at one of the highest points of the Pacific Road, reported that a memorial had been presented to Congress on the subject, and favorable action was hoped for at an early day.

The proceedings of the meeting have come too late to be further noticed in this number.

6. *American Naturalist.*—The press of the American Naturalist, at Salem, Mass., will issue, according to a recent announcement, a number containing abstracts of papers read at the meeting of the American Association at Indianapolis, and the address of Dr. Hunt, the retiring President.

OBITUARY.

Edward Claparède.—One of the most industrious and learned of the younger zoologists of Europe, Edward Claparède, has lately (June, 1871) died at Sienna, at the age of 39. His memoirs, begun in 1857, have been issued with remarkable rapidity. His principal works consist of his monographs on the Infusoria and Annelids. In all his papers, his thorough physiological and anatomical training is perceptible, his details being always discussed in all their general bearing. Living in Geneva, and a pupil of Johannes Müller, he wrote with equal facility French and German: an admirable draughtsman, his many papers, which have appeared in the principal German and French scientific periodicals, are excellently illustrated and wonderfully accurate.

His qualities as an original and independent observer are best seen in his larger memoir on the Annelids of the Gulf of Naples, and his observations on the Anatomy and Embryology of the Invertebrates made on the coast of Normandy. His style was remarkably clear and his information very extensive, as is shown from his scientific reviews in the Archives de Genève. Thoroughly independent in his scientific opinions, he never allowed himself to be carried away by weight of authority, and no scientific charlatan protected by eminent names was allowed to pass current; his reviews and criticisms were often sharp, but always just, and never personal. The Academy of Geneva, where he was Professor of Anatomy, will find it difficult to fill the place of one who, in spite of his failing health, showed an enthusiasm for his science rarely equalled. A. AG.

ALEXANDER KEITH JOHNSTON, the geographer, died at Edinburgh, on the 11th of July, aged sixty-eight.

V. MISCELLANEOUS BIBLIOGRAPHY.

1. DR. ELLIS'S *Life of Sir Benjamin Thompson, Count Rumford*,* is written in the best taste as a literary production, and sets the character of this philosopher in its true light as an original genius and able investigator. The memoir opens with a happy parallel between Benjamin Franklin and Benjamin Thompson, "who were born within twelve miles of each other, under like straits, in humble homes; both of English lineage, of an ancestry and parentage yeomen on the soil on either continent, without dependence upon inherited means, or patronage, or even good fortune." Yet it appears they were never acquainted personally, although they were for thirty years contemporaries, of similar tastes and pursuits, and were intimate in friendship or correspondence with some of the same distinguished persons. Both labored in an unselfish spirit, and both succeeded in doing what has been for the good of a common humanity, "without distinction of class, and without a view to any personal ends of thrift or glory." If Franklin, whether by good fortune or a keener sense, attained a higher fame as a statesman, there can be no doubt that Thompson was more eminent in his scientific pursuits and attainments, and that is no small praise in view of all that Franklin did in science. As historians of science which is cosmopolitan, we can overlook, if we cannot wholly excuse, the course which misled Thompson to take up arms against his country, under circumstances of a highly irritating character which go far to excuse what we have reason to know he often regretted. Dr. Ellis has had access to numerous original sources of information, which have enabled him to correct many errors which had become traditional in the lives of Rumford, and to add a great number of items, both curious and instructive, showing the youth to have been father to the man. His skill with his pencil was early developed as a caricaturist, and in sketches, as well as in attempts at wood engraving, he showed considerable skill when he was not over fifteen years of age. His letters of enquiry, addressed at about the same age to his early friend Loammi Baldwin, touch on many subjects of a scientific nature, which few boys at that age are wont to trouble themselves with; this brief note, dated "Woburn, August, 1769," will serve as an example:—

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* Memoir of Sir Benjamin Thompson, Count Rumford, with notices of his Daughter. By GEORGE E. ELLIS. Published in connection with an edition of his works, by the American Academy of Arts and Sciences, Boston. Published for the Academy by Claxton, Remsen, & Haffelfinger, Philadelphia. 680 pp. 8vo. 1871.

The Complete Works of Count Rumford. Vol. I. Boston: Published by the American Academy of Arts and Sciences. 493 pp. 8vo.

"Sir: Please to give the Nature, Essence, Beginning of Existeuce, and Rise of Mind in General, with the whole Theory thereof, so as to be able to answer all Questions relative thereto. Yours, BENJAMIN THOMPSON."

Dr. Ellis copies from the old memorandum book of young Thompson, which has fortunately been preserved, a number of very curious things; among them, "An Account of what expence I have been at towards getting an Electrical Machine." Commencing "1771, July 1, '⅛ pd. brass wyer,' and giving item by item over 'iron wyer,' 'Pewter to make bullets,' 'Old brass,' '1 Book Brass Leaf,' 'Oil bottles,' 'Copper Filings,' 'Silver Brons,' 'Shellac,' 'Laquer,' 'Varnishing brush,' 'Aqua fortis,' &c., &c.," which is soon followed by "An Account of what Work I have done towards Getting an Electrical Machine." He was then 17 years old, and had enjoyed no advantages of education beyond the most elementary training of a rural school, these early efforts "towards getting an electrical machine," being a foreshadowing of the energy and personal attention which many years later aided him in his memorable researches upon heat, in which he so broadly laid down the doctrines sustained by most remarkable original experiments, in anticipation of the Mechanical Theory of Heat. Our readers will find Dr. Ellis's memoir of Rumford a most entertaining and instructive portraiture of this remarkable person. It will not be forgotten that he was the originator and founder of the Royal Institution of Great Britain, where Davy, Faraday and Tyndal have found the chief theater of their memorable labors. It is fitting that the American Academy of Arts and Sciences at Boston, as the custodian of his funds, specially entrusted to them to promote research in his chosen departments of *Light* and *Heat*, should publish "The complete works of Count Rumford." They will probably fill four volumes. B. S.

2. *On the direction and force of the Wind, with the fall of Rain and Snow at Wallingford, Conn., from observations made by Benjamin F. Harrison, M.D., and reduced by* FRANCIS E. LOOMIS, Ph.D., Prof. of Physics and Industrial Mechanics, Cornell University. pp. 62. (From the Transactions of the Conn. Academy of Arts and Sciences, Vol. II, 1871).—The observations discussed in this paper were made at Wallingford, a town about twelve miles north of New Haven. The wind observations were made with a self-recording apparatus similar in most respects to Osler's self-recording anemometer, and embrace a period of five years. The observations were reduced separately for each hour of each month of the year; and the results are graphically represented upon a Plate which exhibits in a very striking manner the diurnal changes in the wind's direction. During six months of the year, viz: from October to March, inclusive, this diurnal change is small, but during the other six months the diurnal change is very great, and is most remarkable in May and August, when during the forenoon the average wind blows almost directly from the north, and in the afternoon almost directly from the south. This remarkable change in the average direction of the wind is traced to the changes of temperature of the land and the neighboring water; and the cause

assigned seems adequate to account for all the facts at present known in this vicinity. It is much to be desired that a similar series of observations should be made at New Haven, for the purpose of developing still more precisely the laws which govern the diurnal and annual changes in the wind's direction.

The Wallingford observations also show the mean force of the wind, together with its diurnal and annual changes, but in a manner less satisfactory than they show its direction.

The same article furnishes the fall of rain and snow at Wallingford for a period of twelve years, from which it appears that the average annual precipitation at Wallingford is fifteen per cent greater than at New Haven.

The good judgment and perseverance of Dr. Harrison in making these observations are greatly to be commended, and we hope his example may be imitated by many other observers in our country. The results of such observations are not only important in their bearings upon questions of pure science, but they are intimately connected with the interests of every individual, with the prosperity of agriculture, and the security of commerce.

3. *Annual Report of the Board of Regents of the Smithsonian Institution*, showing the operations, expenditures and condition of the institution for the year 1869; 430 pp. 8vo. Washington, 1871. —Besides the report of the Secretary, this valuable volume contains the following memoirs, selected from various sources:—Life and works of Kepler, by M. Berthrand; Eulogy of Thomas Young, by Arago; Memoir of A. Bravais, by E. de Beaumont; Life and Scientific Labors of S. Marianini, by C. Matteucci; Chemistry of the Earth, by T. S. Hunt; Electrical Currents of the Earth by C. Matteucci; on the Phenomena of Flight in the Animal Kingdom, with many illustrations, by M. Marey; on the Northern Seas, by M. Babinet; Report of the Trans. Soc. Phys. and Nat. History of Geneva; Coronado's March in Search of the "Seven Cities of Cibola," and discussion of their probable location, by Gen. J. H. Simpson, U. S. A.; on the Social and Religious Condition of the Lower Races of Men, by Sir John Lubbock; on the Principles and Methods of Paleontology, by T. H. Huxley; Remarks on the "Casa gicantesca" of Yzamal in Yucatan, by Dr. A. Schott; Forests and their Climatic Influence, by M. Becquerel; on a Meteorite, from Washington Co., Wisconsin, by Dr. Fr. Brenndecke; Remarkable Forms of Hailstones in Georgia, by S. Abich; Eruption of the Volcano of Colima, by C. Sartorius.

4. *Elemente der Mineralogie*, von DR. CARL FRIEDRICH NAUMANN. 8th enlarged and improved edition, with 836 figures, 606 pp. 8vo. Leipzig, 1871 (W. Engelmann.)—Dr. Naumann's Elements of Mineralogy is the most prominent of recent German Mineralogical text-books. Its editions have followed one another rapidly, and the present is the eighth. It is a complete but condensed work, its descriptions being brief, and also its notices of localities and its mention of chemical composition. The figures of crystals are numerous and excellent.

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Art. XXXII.—*On the Connecticut River valley Glacier, and other examples of Glacier movement along the valleys of New England;* by James D. Dana.

In former papers* I have spoken of the existence of a Connecticut valley glacier in the Glacial era; understanding by the expression, as I have said, that the under part of the great continental glacier lying in the Connecticut valley-depression moved *in the direction of the valley*—either while the great glacier was at its maximum thickness and held on its southeasterly course, or after its partial decline.

I propose now to give more fully the evidence with regard to the Connecticut valley movement; and, further, to show that other large valleys of central and western New England had also, in the same sense, their valley-glaciers—that is, they determined the direction of the ice that lay within them.

The facts appealed to in support of the conclusions are partly of my own observation; but they are mostly drawn, for Massachusetts, from the Report on the Geology of the State by Dr. E. Hitchcock, who labored with much enthusiasm in this department of the science; for New Hampshire, from an unpublished map by Prof. C. H. Hitchcock, kindly furnished me by its author; for Vermont, from the Vermont Geological Report, which contains the numerous observations of Prof. C. B. Adams, Prof. C. H. Hitchcock, A. D. Hager and Zadock Thompson; for eastern New York, between New England and the Hudson river, from the volume of the New York Geological

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* Manual of Geology, 1863, p. 544; This Journal, II, xxxv, 249, 1863; Trans. Connecticut Acad., ii, 45; This Journ., III, i, 1, and 125.

Reports by Wm. W. Mather, an assiduous laborer in this field of research.

We learn, first, from the scratches on the rocks *outside* of the larger valleys of New England—that is, over its higher lands—that the general course of the continental glacier covering New England was between S. 20° E. and S. 50° E. The true course, deduced from the magnetic, is here given, and so throughout the following pages.

On the high region of western Connecticut (1000 to 1200 feet above the sea), about Warren and Litchfield, the author found the courses of the scratches S. 29° E.; more to the west, east of Kent, on Kent mountain, S. 19° E.; to the south of Kent, about Newtown, S. 38° E. Percival observes that over this western part of Connecticut the direction of the transfer of drift was to the S.S.E. (probably meaning S. 20°–25° E.); and he cites as proof the distribution of blocks of limestone over Litchfield county from Canaan, and also of other rocks over the same and other counties. Mather gives for the direction in Litchfield county, Conn., near Norfolk, S. 20°–25° E., and Hitchcock, for that on Mt. Tom, the highest elevation near Litchfield, S. 17°–22° E.

West of the State of Connecticut, between it and the Hudson river in Dutchess county, not far west of Arthursville, I obtained for the course of scratches (which were common over the region) S. 24° E. Mather found in Putnam county (south of Dutchess), near Patterson, S. 17° E. to S. 22° E.; in Dutchess county, mostly between S. 15° E. and S. 30° E., but in some places S. 35° E.; and north of Dutchess county, in Columbia county (west of Massachusetts), mostly S. 18° E. to S. 30° E., with some on the mountain top east of Shaker Village and elsewhere in that vicinity, S. 45° E.

In the Taconic range, along the western boundary of Massachusetts, Dr. Hitchcock found the course of the scratches on the top of Mt. Everett (2600 feet above the sea) and on the adjoining Mt. Washington S. 18° E.; 15 miles farther north, on top of Tom Ball in Alford, 30 miles north of Mt. Washington, S. 43° E.; on the east slope of the Taconic ridge near Pittsfield (in same latitude nearly with the Shaker village above alluded to) and at Egremont, on the west slope, about S. 50° E.; a little south of the latter, on Lenox mountain, near the road from Richmond to Lenox, S. 38° E. Scratches observed by the writer on Mt. Everett trended S. 27° E.

Again Dr. H. obtained for the course in middle Granville, 20 miles west of the Connecticut, S. 38° E.; between Otis and Becket, 30 miles west of the Connecticut, and farther north in Windsor, about S.E. For eastern Massachusetts (that is, the part of the State east of the Connecticut), Dr. Hitchcock gives as the average direction S. 24° E. He obtained in Royalston nearly 20 miles west of the Connecticut, S. 18° E. to S. 38° E.

On the higher land of Vermont, away mostly from river valleys, the course of the scratches, according to the Vermont Geological Report, is for the most part between S. 35° E. and S. 55° E. In southern Vermont, on the higher land of Windham, 15 miles west of the Connecticut, S. 40° E.; in Wilmington, S. 29° E and S. 39° E. (intersecting): in central Vermont, in West Hancock, S. 50° E.; in Ripton, S. 60° E. In the northern half of the State, on Camel's Hump, 4088 feet above the sea, S. 55° E.; on Mt. Mansfield, 4430 feet high, S. 55° E.; on Jay's Peak, north of the latter, S. 50° E.; in Stowe, in the valley east of Mt. Mansfield, S. 35° E. Judging from the map in the Vermont Geological Report, which gives some observations not registered in the text, the average course on the higher lands away from the valleys is about S. 50° E.; and the same is not far from the course for the higher lands of New Hampshire, according to Prof. C. H. Hitchcock's map.

The facts show plainly that on the higher lands, both east and west of the Connecticut, and even over the elevated ridges of the Green Mountain range through Vermont, Massachusetts and Connecticut, and also west of this range over the eastern borders of New York, the great continental glacier had a southeastward course; in the latitude of Connecticut, about S. 25° E., and to the northward, S. 35° E. to S. 55° E. With such a course the glacier moved over the elevated lands on the west of the Connecticut river and the elevated lands to the east of that river, keeping onward, with little variation in its main movement notwithstanding the ridges in its course, and following no doubt the general slope of the surface of New England.

But this being true of the movement of its main mass, other facts show that the bottom ice of the great glacier followed often the courses of the valleys beneath it.

1. First as to the *Connecticut river valley ice.* This valley, or great north and south depression of New England, has its termination, as I have elsewhere observed, at New Haven, the Connecticut river channel leaving the valley at Middletown, Conn., and taking thence a southeastward course to the Sound. In the following table, the courses of glacial scratches along the valley are given for comparison with the course of the valley. It commences with localities at the south.

1. CONNECTICUT.	Courses.	Observers.
E. of New Haven bay,	S. 10°–16° W. many	J. D. D.
North of Meriden,	S.	J. D. D.
New Britain,	S. 15° W.	Percival.
Mt. Carmel, 7 m. N. of N. H.	S. 30° W.	W. B. Dwight.
Wadsworth's mountain,	Southwesterly	Mather.
2. MASSACHUSETTS.		
Granby, 7 m. E. of Conn. R.	South nearly	E. Hitchcock.
Mt. Tom,	South "	"
Mt. Holyoke,	South, S. a few degrees W.	"

Massachusetts.	Courses.	Observers.
Sunderland, E. side of Conn. R.	South nearly	E. Hitchcock.
Deerfield, S.E. part,	South "	"
Montague, E. side of Conn. R.	South "	"
Greenfield, W. " "	South "	"
Northfield, E. " "	South "	"
3. Vermont.		
Vernon, for 2 m. W. side of Conn. R.	S.	C. H. Hitchc'k
Guilford, 5 m. W. of Conn. R.	S. 8° E.–S. 13° E.	C. B. Adams.
Brattleboro, for a great distance along C.R.	S. and S. 8° E.	C. B. A.
Dummerston, near Conn. R.	S.	C. H. H.
Putney,	S. 5°–12° W.	C. B. A.
Rockingham,	S. to S. 2° W.	C. H. H.
Norwich, 2 m. W. of village,	S.	C. H. H.
Norwich,	S. 15° E. and S. 39° E.	
Thetford, W. part of town,	S. 9° E.	C. H. H.
East Fairlee,	S. 6° E.	C. H. H.
Bradford,	S. 19°–30° E.	C. H. H.
"	S. 30° E.	C. B. A.
Newbury,	S. 12°–30° E.	C. B. A.
Waterford and Barnet,	S. 5° E. many; also S. 8° E.	

In New Hampshire, the courses of scratches, as represented on the map of the State by C. H. Hitchcock, referred to above, correspond very nearly with those of Vermont. According to it, scratches trending *west* of south occur in the river towns Chesterfield, Walpole, Hanover, Oxford, Haverhill, and still farther north, along the Passumpsic, in Monroe and towns adjoining it on the east.

Now the average course of the whole Connecticut river valley and of the Passumpsic valley, its true continuation northward, is about S. 9° W. But its different parts vary from this: that north of Massachusetts trending about S. 12° W.; that in Massachusetts, S. 6° W., but varying in the southern part to S. nearly; that in Connecticut from the Massachusetts line to Hartford, S. 3° W.; that from Hartford to New Haven, S. 18° W.; and the whole average for Connecticut, S. 15° W.

The table shows that the courses along the valley from New Haven to White River Junction or Norwich, Vt., are between S. 16° W. and S. 9° E., instead of between S. 30° E. and S. 50° E., like the scratches over the higher lands; and that, therefore, the average difference between the general course of the glacier and its course along the Connecticut valley is over 30°, that is, in the valley there are upward of thirty degrees more of westing.

In Connecticut, in which the average course of the valley is S. 15° W., the common course of the scratches is S. 15°–16° W.

In Massachusetts, in which the valley trends S. to S. 6° W., the scratches trend a few degrees west of south on Mts. Holyoke and Tom, or in part at least, as stated by Hitchcock; and as these are much the highest points in this part of the valley (their tops 1126 and 1211 feet above the sea level), they afford consequently the best evidence of the average direction of the movement in that region.

In Vermont, where the course of the valley for the more southern half is S. 12° W., the scratches trend S. to S. 13° E. But north of White River Junction the course of the scratches varies between S. and S. 30° E., yet many scratches at the farthest point, near the mouth of the Passumpsic, are S. 5° E. to S. 8° E.

In the part of the Connecticut valley south of Vermont the scratches conform closely in direction to the trend of the valley, and are the only scratches; while to the north there is a general southerly course in the scratches of the Connecticut river valley, yet at the same time about 15° less of westing than in the average trend of this part of the river. Moreover, in this upper part of the valley there are often, besides the valley set of scratches, another set having the southeasterly course of the great glacier.

The width of the region bearing the north-and-south scratches of the valley is generally twenty to thirty miles, but sometimes more. Going east or west of this there is a change more or less gradual to the course of the great glacier, and often also other scratches conforming to its course occur. In Massachusetts, in Heath, 15 miles west of the Connecticut, the course of the scratches given by Hitchcock is south with some westing, and the same on Mt. Pocomptuck in this town, 1888 feet high; and in Rowe, 20 miles west of the river, the course is S. 2° W. In southern Vermont, in Halifax, west of Vernon, and 10 miles west of the Connecticut, the directions given by Hitchcock are mostly S. 12° W.; but also, in *West* Halifax, 15 miles from the Connecticut river, S. 53° E.; in Marlboro, north of Halifax, S. 20° E. on high land; and also, at another locality, two courses, S. 7° W. and S. 53° E., intersecting.

The facts show beyond question that *the abrading agent of the Connecticut valley moved mainly in the direction of the valley.* The less degree of conformity of direction between the scratches and the valley in its *upper* portion is what should be expected; and so also the intersecting southeasterly scratches of this portion, and also of the region on either side of it a little distant from the river.

2. *Upper Champlain Valley.* The main part of Lake Champlain is the region of a vast plain—though a plain of water—and little or no conformity to its direction in the course of the scratches on its borders could be expected. At Burlington the courses are S. 19° E. to S. 31° E.; in Shelburne, south of Burlington, S. 17° E. to S. 29° E.; which courses show apparently that some diverting effect was produced by the main ridge of the Green Mountains. But the southern prolongation of the lake from Addison, and even from Ferris, southward to White-

hall, a distance of 40 to 50 miles, is very narrow, and occupies a proper valley, and here the scratches are parallel mostly to the trend of the lake—which trend is nearly north and south, excepting for the southern part, where it is about 16° *west* of south (S. 16° W.). Along this more southern portion, in Benson, the course of the scratches, according to the Vermont Report, is S. 8° E., S. 12° W., S. 15° W.; and in Orwell, just north, S. 8° E., S. 12° W. Farther north, in Bridport, the course is S. 20° W.; in Addison, S. 17° W. and S. 13° E.; at Larrabee's Point, S. 4°–12° E.; at Crown Point in New York, opposite to Bridport, S. 2° E. on the west side, and S. 27° E. on the east. In Putnam, N. Y., west of Benson, according to Mather, S. 10°–15° W. The conformity of the course of the scratches to the trend of the valley in its southern half is very close; in its more northern part, where, opposite Addison and beyond, the lake is over two miles wide, scratches both of the valley course and of the general course of the glacier occur together. The divergence in all, from the S. 40°–55° E. of the higher lands of the State, is very wide.

3. *Lamoille River Valley and Winooski River Valley.* These rivers, in the northern half of Vermont, rise in the *eastern* part of the State and pass through the Green Mountains, the former north of Mt. Mansfield, the latter just north of Camel's Hump; in the case of each, the bottom of the valley where the river passes the line of these mountains is not far from 4000 feet below their summits. The course of each is about N. 15°–20° W. and S. 15°–20° E.

Along each of these valleys, the glacial scratches are closely parallel to its main trend, as shown and recognized by the Vermont geologists. It is strikingly exhibited on a map of the State accompanying the report. On the Lamoille there are the courses S. 55° E. to S. 85° E.; on the Winooski, the courses S. 60° E., S. 80° E., and even east-and-west in one case.

4. *Otter Creek Valley.* Otter Creek flows northward along the great valley in the southern half of Vermont, just west of the axis of the Green Mountains, passing by Rutland, Brandon, Salisbury, toward the southern end of the broader part of Lake Champlain. Its general course is about N. 15°–20° W. and S. 15°–20° E. The glacial scratches in the valley have the courses S., S. 12° E., S. 15° E., S. 20° E.

5. *Merrimack River Valley* (New Hampshire). The conformity between the courses of the scratches along this valley above Lowell and its trend is well shown on the map of New Hampshire by Prof. C. H. Hitchcock. The average trend of the valley is but a little east of south, and the same is true of the scratches.

We have thus evidence of the existence during some part of the era of ice not only of a glacier movement in New England along the Connecticut river valley, but also of one along the upper Champlain valley, the Lamoille valley, the Winooski valley, the Otter creek valley, and probably the Merrimack valley; and many of the courses of scratches observed in other parts of Vermont and New Hampshire have divergences from the normal course of the great glacier, which are probably due to the valley-depressions of the surface. Among these smaller valleys are perhaps those of the Queechee, Black, Middlebury and White rivers of Vermont and the Deerfield of Massachusetts; for the existence of an *independent* glacier in each of these valleys is recognized as probable by Prof. Hitchcock, on the ground of the conformity between the direction of the scratches and the valley, although the iceberg theory is adopted by him for all the rest, even the Lamoille, Winooski and Connecticut. The writer has elsewhere mentioned the evidence in favor of a Hudson river glacier movement, and of another in the Mohawk valley running easterly through central New York; and further, of one along the St. Lawrence valley, the scratches in it following its course according to the observations of Dr. Dawson.

The facts are sufficient to prove that examples of valley movements of glacier ice must have been common over the continent in the Glacial era, or rather the rule for all the larger valleys. It is hence evident that no observations on glaciers are complete which do not take into account the surface features of the country. Prof. Hitchcock recognized the deflecting influence of the Connecticut and Lamoille valleys; but the deflection, in his view, was that of icebergs. Besides the argument against the iceberg hypothesis elsewhere presented, New England affords another in the fact that if there were, at the time, a submergence to the depth required to overcome the obstacles to a southeast movement offered by the southerly trend of the mountains, there would still have been no southeasterly flow of waters over its surface, since no currents having this course exist in the adjoining seas. And further, the necessity of helping out the iceberg theory by bringing in glaciers for some of the smaller valleys, because icebergs could not be supposed to have worked their way along them to do the scratching, affords another strong argument against it.

The question now comes up, whether the scratches in the valleys were made in the Glacial era while the glacier was of quite or nearly its maximum thickness, or during the decline of the glacier, when its thickness was so diminished as to make the ice of the valleys essentially independent glaciers.

With regard to the Connecticut valley ice, the following evidence appears to show that the movement took place while the continental glacier still had its continental, or at least its New England, movement. *a.* In Massachusetts and Connecticut the only scratches in the valley are those trending south or *west* of south, and they are often very deep; even the tops of Mt. Tom and Mt. Holyoke have only these scratches. This uniformity seems to prove that the direction of movement thereby indicated characterized the ice of this part of the valley through *the whole of the Glacial period.*

b. Again, if a local glacier occupied the valley having a thickness of say one, two, or three thousand feet, or such as would lie below the level of the Green Mountain summits, the glacier would have had through its breadth a nearly southerly course corresponding to the trend of the valley, and in that case southerly scratches should have existed over the whole surface, even localities remote from the Connecticut river—*where they are not found.*

In another place I have supposed that the southeasterly course which occurs in the scratches to the west of the Connecticut river might have been a resultant between the tendency to a southerly movement down the valley, and that down the slope into the valley. But this was so only to a very small degree. For the ice, after passing over the valley, resumed on the east its southeastward scratching.

c. In the part of the Connecticut valley north of Massachusetts, the course of the scratches is not that of the valley, but differs 10° to 15° from it to the *eastward.* This greater easting shows that the southerly movement of the ice induced by the valley was modified by some force pressing it eastward, and this force could only have been that due to the movement of the general glacier. Hence it proves that the general glacier existed at the time in nearly or quite its full force.

We may conclude, therefore, that the valley ice of the Connecticut had through its southern half (across Massachusetts and Connecticut) its own independent southward motion, mostly unmodified, during the whole progress of the Glacial era. But along the more northern part of the valley, there were the modifications in the valley movement just pointed out, and also scratches made by the general glacier. If the southeasterly scratches (those of the general glacier) should be found to be the older of the two sets, we should infer that when they were made the general glacier was then the thickest; but the facts would not prove that the thickness had been so far diminished as to leave the Connecticut valley glacier wholly an independent one. Prof. Hitchcock has stated as his belief that the southwesterly scratches were the oldest, but admits that there is much doubt with regard to it.

This movement of the bottom of a glacier six or eight thousand feet thick along a different course from its main mass wherever it lies in great valleys, is a necessary result of mechanical law. It moves just as thick pitch poured over a sloping surface in which there are a few large groovings would move, the mass following the general surface, and the portions in the grooves nearly or quite the course of the grooves. The thickness of the ice that followed the course of the valley was at least 2000 feet; for the southerly scratches occur not only on the summits of Mt. Tom and Mt. Holyoke, but also on the top of Mt. Pocomptuck in Heath, 15 miles west of the Connecticut, the height of which, as stated, is 1888 feet.

As to the Lamoille, Winooski and Otter creek valleys, the case is somewhat different; for if the movement of the ice in the valleys took place when the great glacier was in full force, it was a movement in each *up the valley.* The valleys are, however, of gradual slope—that of Otter creek extremely gradual—and facts show that the ice is often moved up slopes many hundreds of feet. Dr. A. S. Packard, Jr., mentions the occurrence of fossils in the drift on Mt. Katahdin (Maine) at a height of 4000 feet above the sea, which must have been brought from the low country to the north where such fossils are found in place. As Dr. Packard observes, such facts show that icebergs were not the transporting agents.

It is, however, possible that each of these three valleys had its independent glacier during the melting of the ice. But if so, the great glacier must have been removed wholly out of the way of the valley glacier, so as to be no impediment to its movement down the valley; and it seems probable, from the small extent of these valleys, that by the time the general glacier had got out of the way, the valley ice would also have mostly disappeared. It is quite probable that a careful study of the scratches along one or another of these valleys may decide this interesting question.

It seems to be a natural consequence of a gradual melting of the great glacier, that sooner or later parts of the ice should have become independent and taken independent movements. We should naturally look for this independence at least in the large valley of the Connecticut river. A thinning of the ice to 2000 feet would necessitate, it would seem, a valley movement southward. And yet, as has been observed, the evidences of such a glacier movement do not exist—that is, the scratches are confined to so narrow a band along the center of the Connecticut valley as to show that they were not made by an independent Connecticut valley glacier. How then can we reconcile the fact that the ice must have thinned down to 2000 feet, 1000 feet, and so on, and yet had no movement as a separate glacier? The explanation is this:—The melting of the ice took place in the early part of the Champlain era—an era of subsidence for New England and a large part of the continent (and therefore favorable to the melting); and this subsidence was greatest in New England to the north, having been at least

325 feet in the latitude of Burlington; nearly 150 feet near the northern boundary of Massachusetts, one hundred miles from the termination of the valley (the highest terrace on the river in Hinsdale, New Hampshire, being 159 feet above the river, according to the Vermont Report); and 45 to 50 feet at New Haven, the southern end of the Connecticut valley. Such a subsidence would have diminished the average slope of the whole valley about *one-and-a-half feet a mile.* For the southern half, from northern Massachusetts to Long Island Sound—100 miles—the slope, which now averages *two* feet a mile, would have been reduced to *one-and-one-tenth* of a foot a mile; and from Springfield down, which is 60 miles from the Sound, and the height of the water level only 64 feet above the Sound, making the average slope below about one foot a mile, and where the Champlain subsidence was at least 60 feet more than at New Haven on the Sound, there would have been no appreciable slope in the waters; the basin, as it is designated by Hitchcock, from Middletown in Connecticut to Holyoke in Massachusetts, would have been strictly a basin.* Under such circumstances the ice along the valley would have lost all motion. The same condition of rest would have belonged to the ice of other north-and-south valleys of as small rate of descent; but not necessarily to east-and-west valleys like the Lamoille and Winooski.

High up even the north-and-south valleys, where the slopes were not sensibly changed by such a subsidence, local glaciers might well have existed. Evidences of them in the region of the White Mountains have been pointed out by Dr. A. S. Packard, in an excellent memoir on the Glacial Phenomena of Labrador and Maine (94 pp. 4to), published in Volume I of the Memoirs of the Boston Society of Natural History (1867); also by Professor Agassiz, in the American Naturalist for November, 1870, who states that he observed the marks of local glaciers in the White Mountain region in the year 1847, soon after his arrival in this country.

In the foregoing pages the facts from the State of Maine have not been referred to. These are well discussed by Dr. Packard in the memoir just referred to, in which he recognizes and applies the principle discussed in this and the writer's former papers on the valley glaciers. He observes that of the eighty localities of scratches that have been noted in Maine, the scratches in sixty-two have a southeasterly course; that the southeasterly course of the glacial grooves and striæ is especially marked in the interior of the State on the high lands and low mountains; but, approaching the coast, the evidence shows that the glaciers moved down the river valleys, and thus assumed a more north-and-south course, and at times, owing to local trends in the depressions, were even deflected so as to flow in a direction a few degrees west of south. The facts in Maine are just such as are general to New England.

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* In order to deduce the amount of subsidence for any place on the river from the height of the highest terrace above the ordinary level of the river, it is necessary to deduct first the height of the lower flats. This would give for the amount at Hinsdale 138 feet, which is 88 to 93 greater than at New Haven; and for the amount at Springfield, where the highest terrace is 136 feet, it would give 115 feet, or 65 to 70 feet greater than at New Haven. Such calculations may be in error, and generally will give less than the actual amount, because the height of the terrace depends on the amount of *excavation* that has taken place since the land reached its present level; and this is in most cases less than the amount of elevation.

The same principle is recognized by Prof. N. S. Shaler in the Proceedings of the Boston Society of Natural History, for 1870. Other similar facts have been recently pointed out in States to the west of New England. When the applications of the principle are studied out over the whole continent, we shall understand better than we now do the sources of the varied movements in the great glacier.

ART. XXXIII.—*The Paragenesis and Derivation of Copper and its associates on Lake Superior;* by RAPHAEL PUMPELLY.

II. *Paragenesis of the Minerals associated with Copper.*

No. 1. CAPEN VEIN.—This is apparently a true fissure vein. It occurs in a compact and very tough melaphyr, which is exceedingly chloritic near the vein. All the joints within a distance of several yards from the vein are covered with a coating $\frac{1}{16}$ to $\frac{1}{2}$ inch thick, of dark-green and bluish-green chlorite, having a combined fibrous and foliated structure oblique to the joint surfaces. The melaphyr is rich in magnetite. Sheet copper was found in mining, but not in paying quantity.

1. *Laumontite*, in thin seams.
2. *Prehnite*, in seams which cut through those of laumontite, also between symmetrically arranged bands of laumontite.
3. *Chlorite*, as destroyer and replacer of prehnite, and as lining of cavities in the latter.
4. *Analcite*, in clear crystals on the prehnite and chlorite.
5. *Calcite*.

No. 2. HURON MINE.—1. *Laumontite*, in thin crystalline bands on the sides of a cavity; the free ends of the opposed crystals nearly meet.

2. *Prehnite*, filling the space between the bands of laumontite.

No. 3.* COPPER FALLS MINE.—Fissure vein. 1. (?) *Natrolite*. 2. *Laumontite*. 3. *Analcite*.

No. 4.* SAME VEIN.—1. *Apophyllite*. 2. *Copper*. 3. *Orthoclase*.

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* Taken from a list given by Hilary Bauerman, Quart. Journ. Geol. Society, Nov., 1866.

No. 5.* Bay State Mine.—1. *Prehnite.* 2. *Quartz.* 3. *Copper.* 4. (?) *Laumontite.*

No. 6.* Phœnix Mine.—Fissure vein. 1. *Laumontite.* 2. *Quartz.* 3. "*Green-Earth.*"

No. 7.* Bay State Mine.—Fissure vein. 1. *Quartz.* 2. *Apophyllite.* 3. *Calcite.*

No. 8.* Bohemian Mine.—1. *Analcite.* 2. *Copper.* 3. *Orthoclase.*

No. 9. Amygdaloid Mine.—Fissure vein. 1. *Prehnite*, in its characteristic reniform shape.

2. *Quartz*, in small crystals on the prehnite.

3. *Analcite* crystals, covering the quartz.

4. *Orthoclase* crystals, on the analcite and quartz.

No. 10. Bay State Mine.—Fissure vein. On the soft brown gangue. 1. *Analcite*, lining part of a vugg. The crystals are ¼ inch in diameter, often white and transparent, but very much fractured. Near the contact with the rock they are often reddened internally and much altered, and then surmounted by the next member.

2. *Orthoclase*, in the usual minute crystals, some of which are scattered over the altered analcites.

No. 11. Amygdaloid Mine.—Fissure vein. 1. *Prehnite*, in the characteristic reniform shape, forming the body of the specimen; fresh-looking on the free surface, but on the under broken side somewhat porous, with earthy fracture, and then rather intimately associated with datolite and a soft green (chloritic ?) mineral.

2. *Copper*, in films traversing the prehnite, and molded to the reniform surface. While the under surface of the copper bears the impression of the prehnite, the upper surface, now free, bears that of some mineral that is gone; threads of copper rising from this free surface ¼ inch are crystallized at the tips, where they stood above the mineral that has disappeared.

3. Minute grains of a hard yellowish-white mineral, sprinkled like meal over the prehnite and copper; under the microscope appear to consist of sheaf-like clusters of minute rhomboidal plates; fuses with difficulty.

4. *Datolite*, in microscopic crystals on No. 3; others, one line in diameter, rosy, with suspended flakes of copper, lie upon the prehnite.

No. 12. Amygdaloid Mine.—(Fissure vein.) On the gangue—here chloritic—lie, 1. *Calcite*, imbedded between the gangue and No. 2.

2. *Prehnite*, forming the greater part of the specimen, and having a tolerably fresh luster.

3. *Copper*, in grains, flakes and threads conforming to the radiating cleavage planes of the prehnite.

4. *Datolite;* compact amorphous, white translucent mass, covering the prehnite with a layer of which ¾ inch thickness, still remains. The copper threads do not penetrate it.

No. 13. PEWABIC COPPER-BEARING BED.—This specimen—about 2½ inches by 3½ by ¾—is evidently from the interior of a druse, to whose wall it was attached by only a small part of its surface. The body of the specimen is copper, very cavernous, much of it pseudomorphous after laumontite. The copper is very thickly bestrewn with small green crystals of quartz—prisms terminated at both ends,—which are however *older* than the copper. On the sides and around the edges of the specimen there are beautifully modified scalenohedrons of calcite. The successions are:

1. *The rock or mineral* to which the laumontite was originally attached, and which has disappeared.

2. *Laumontite* or leonhardite; has also disappeared; the prisms were ⅛ to ⅓ inch long, terminated at one end with a hemidome.

3. *A mineral*, now gone, which must have been present to support the quartz crystals (see Quartz). It may perhaps have been the alteration-product of the laumontite or an enclosing mineral; laumontite crystals occur frequently enveloped, except the base, in calcite.

4. *Quartz*, in prisms $\frac{1}{20}$ to ⅕ inch long, often terminated at both ends. They occur on parts of nearly every one of the pseudomorphs after laumontite; the copper is moulded to them, giving casts even of the striæ on the prisms, and they frequently pass entirely through the pseudomorphs after laumontite, so that the two ends of a quartz prism frequently just appear on opposite sides of the pseudomorph and transmit light. In some instances the quartz crystals are so numerous as to touch each other, but they are often wholly isolated, and supported only by the copper which is younger.

The quartz crystals contain minute, brilliant particles of copper, wholly isolated, in the interior.

5. *Copper*, in the form of laumontite, preserving often the sharpness of the angles and smoothness of the faces of the original mineral, when seen by the naked eye; under the glass the surface is less even. The pseudomorphs are not solid copper, as will appear in describing other specimens.

6. *Chlorite?* a soft, light-green mineral in minute hemispherical forms, with radiating structure, scattered over the quartz and copper. Wherever this mineral lies upon the quartz crystals, these are more or less penetrated by it, and some of them are eaten through and through to such an extent that the crystalline form is no longer recognizable.

7. 2*d* *Copper Calcite;* Calcite crystals—scalenohedrons—$\frac{1}{8}$ to $\frac{3}{4}$ inch long, lie on the sides and around the edges of the specimen. These crystals, in forming, adapted themselves with partially entering faces to the rough surface of the preëxisting quartz and copper. Some of the calcite crystals contain brilliant isolated films of copper, which must have been formed at least after the calcite had begun to crystallize, and is therefore younger than the copper previously mentioned.

8. *Datolite*, in exceedingly minute crystals, lying on both the chlorite and calcite; they are less than $\frac{1}{300}$ inch in diameter, but the datolite form is distinctly visible under the microscope; they fuse easily with the characteristic green flame.

No. 14. PEWABIC COPPER-BEARING BED.—1. *The rock* or mineral to which the laumontite was originally attached, which has disappeared, copper now forming the support of all the members.

2. *Laumontite*, of which only the form now remains.

3. *A mineral*, now gone, which seems necessarily to have been present to support the isolated crystals of quartz.

4. *Quartz*, in minute prisms, containing brilliant particles of copper.

5. ? *Calcite*, represented only by impressions in the copper. This calcite may, perhaps, be older than some of the foregoing members.

6. *Copper*, now forming the body of the specimen. It is very cavernous, and besides forming in places pseudomorphs after laumontite, it is the support of every member of the series. That it is younger than the quartz crystals is shown by the fact that on removing these, perfect casts of them are visible in the copper. The copper also contains impressions of calcite crystals (see above).

7. *Chlorite?* the same mineral as the 6th member of No. 13, and occurring in the same manner.

8. *Calcite;* a few small scalenohedrons planted on the copper in the impressions of the older calcite = 5th above.

No. 14*a*. *Copper after laumontite*, from the PEWABIC COPPER-BEARING BED.

The upper face of this specimen is part of a partially filled cavity in a cupriferous and highly altered amygdaloid; the lower, or broken face, is a portion of the altered amygdaloid itself. The general appearance of the specimen at first glance is that of a drusy cavity, nearly filled, except in the middle, with broken crystals of calcite, whose interiors contain many thin plates and threads of native copper.

The amygdaloid is a soft compact brown and green rock with earthy fracture,—an altered amygdaloidal melaphyr. The small amygdules near the wall of the larger cavity are of calcite.

The pseudomorphs of copper after laumontite are prisms $\frac{1}{8}$ to $\frac{1}{2}$ inch long and about $\frac{1}{8}$ of an inch square, and are terminated with a hemidome; they are each attached by one end to the wall of the cavity and project out toward the interior. The angles are often sharp, though in some instances the junction of two faces of a prism presents something of the appearance of a copper cast made in a mould whose two halves fit only imperfectly together. Sometimes, under a strong glass, the joining is clearly imperfect, and the pseudomorph has the effect of a prism built with four badly-soldered plates of metal.

Minute prisms of quartz (colored green by the chlorite-like mineral mentioned in specimens No. 13 and 14) project from the interior of the pseudomorphs, through the copper, to $\frac{1}{100}$ of an inch above the surface.

In one place I cut to the depth of $\frac{1}{12}$ of an inch in solid copper; but a cross fracture in another prism showed that the copper was, there, a mere superficial film, while the interior was occupied by a confused and rather porous mass of quartz prisms, copper, and the green chlorite-like mineral mentioned above. It is these quartz crystals whose ends just pierce the copper coating. In some instances a prism of quartz terminated at both ends passes entirely through the pseudomorph and appears on both sides, and allows the light to pass through. After removing a quartz crystal from the copper, a perfect cast, even to the horizontal prism-striæ is found in the copper.

The copper-surface of the pseudomorphs seems nearly smooth to the naked eye, but under a strong glass it appears not only often perforated with holes, but it often shows flakes of copper rising on edge to a height of $\frac{}{100}$ of an inch above the face.

These pseudomorphs before the breaking of the specimen were imbedded in the interior of scalenohedrons of calcite, except at the attached ends of the prisms. At the contact planes between the calcite and the pseudomorphs, the former seems to adapt itself fully to all the irregularities of surface of the latter.

On the bottom of the specimen the calcite amygdules exhibit marked signs of change to datolite. The transparent crystals become gradually opaque, with a pearly lustre on the cleavage planes, and a little farther away this condition merges almost insensibly into a lustreless white mass composed of an aggregation of exceedingly minute crystals, which exhibit the datolite form under the microscope, and fuse easily with the characteristic green flame before the blowpipe. The same change is visible, in places, on the crystals of calcite enveloping the pseudomorphs after laumontite.

The relative ages here appear to be, 1, *The amygdaloid*, though probably not in its present condition; 2, *Laumontite*; 3, *Quartz*; 4, *Copper*, *chlorite-like mineral*; 5, *Calcite*; 6, *Datolite*.

No. 14 (*b*) *Another specimen* from the same locality exhibits,—besides pseudomorphs of copper after laumontite,—pseudomorphs of quartz after laumontite. In these last, the ends of the pseudomorphs are broken off, leaving only the prism. The faces are formed by a tolerably even mass of quartz, on the outer surface of which a crystalline form appears here and there under the glass. The interior of the prism is not a compact mass of quartz, but is nearly filled with quartz prisms projecting from all sides toward the middle and containing minute brilliant and isolated particles of copper.

Near these are the copper pseudomorphs; they are mere hollow shells, scarcely as thick as paper; the angles are sharp and the faces tolerably smooth, but often pierced with holes. The hemidome of one of these is studded with the ends of minute quartz prisms, which occupy the interior of that part of the pseudomorph and project through the copper shell.

In this specimen also, some of the pseudomorphs are imbedded in scalenohedrons of calcite, which sparkle with brilliant particles of copper swimming in the transparent crystals.

In these remarkable pseudomorphs the quartz is undoubtedly the oldest existing intruder, while the copper, which far more generally preserves the crystalline form of the laumontite, seems to be pseudomorphous in, at least, the second degree of removal. Yet in nearly all instances the older quartz is present, occupying a part of the space originally belonging to the laumontite crystal; and very often these quartz crystals are wholly separate from each other and supported only by the younger copper. Something which is now gone must have existed to perform this office of support before the copper was deposited.

No. 15. "RAGGED AMYGDALOID," ALBANY AND BOSTON M.—On the rock lie: 1, *Prehnite*—2, *Orthoclase*, in minute crystals on the prehnite.

No. 16. "EPIDOTE LODE," ST. MARY'S.—In a cavity in the quartz-epidote rock, which forms a frequent feature of this bed, lie: 1, *Prehnite* crystals, disposed as a reniform lining of the cavity—2, *Quartz*, in transparent prisms on the prehnite—3, *Analcite*, crystal ½ inch in diameter, slightly opaque and somewhat cavernous internally, planted on the quartz.

4. *Orthoclase* crystals planted on the prehnite, quartz and analcite.

The prehnite is partially altered, containing cavities lined or filled with a soft green mineral, chlorite or green-earth. There is also a greenish-yellow chlorite-like mineral, which incrusts and has eaten away the surface of the quartz crystals.

No. 17. AMYGDALOID ON THE KEARSARGE LOCATION.—On the rock lie: 1, *Prehnite*—2, *Quartz* on the prehnite.

No. 18. HURON MINE.—On the rock lie: 1, *Analcite*, in a continuous band ½ inch thick, crystallized on the inner face; it is reddish and perhaps much altered, though still hard—2, *Calcite* incrusting the analcite crystals, and occupying cavities in their interior.

No. 19. ALBANY AND BOSTON AMYGDALOID.—The rock of this bed is a wholly irregular mixture of hard light-green amygdaloid and soft brown amygdaloid, in which the vesicular form is frequently lost from the fact that the cavities containing secondary minerals have extended and become merged together, forming a confused patch and vein structure: 1, *Prehnite*, amorphous and altered to a slightly cavernous appearance on the surface—2, *Quartz* in prisms—3, *Orthoclase* in minute crystals chiefly on the altered prehnite, with which its formation is probably connected, and also on the quartz.

No. 20. SAME BED.—On the amygdaloid, which contains quartz amygdules, lie: 1, *Prehnite* penetrated with strings and films of copper—2, *Quartz* in prisms; *chlorite-like mineral* in hemispherical forms, with radiating structure—*Orthoclase* in minute crystals; all these lie separately on the prehnite—3d, *Calcite* covering all the above mentioned members.

No. 21. SAME BED.—1, *Quartz*, in prisms—2, *Chlorite-like mineral* in hemispherical forms, with radiating structure; wherever it is in contact with the quartz it has pitted it and eaten into it—3d, *Calcite.*

No. 22. SAME BED.—On the amygdaloid lie:—1, *Prehnite* crystals in reniform masses—2, *Quartz*, in prisms on the prehnite crystals—3, *Orthoclase; Calcite;* the orthoclase is in minute crystals on the prehnite and quartz.

No. 23. SAME BED.—The amygdaloid on which the following succession occurs consists of quartz and chlorite, and is wholly altered—so much so that the quartz which now composes a large part of it is evidently of the same age as that which follows the prehnite—1, *Prehnite*, in crystalline reniform masses —2, *Quartz* prisms—3, *Copper* in cubes, with octahedral modifications, planted on, and moulded to, the quartz crystals.

No. 24. SAME BED.—1, *Prehnite*—2, *Quartz*—3, *Calcite.*

No. 25. SAME BED.—1, *Analcite* in pellucid crystals—2, *Calcite; Orthoclase;* in this specimen the analcite appears to have incrusted some mineral which has disappeared, and the feldspar crystals occur in the cavity thus formed as well as on the outer surface of the analcite.

No. 26. SAME BED.—1, *Prehnite*—2, *Quartz*—3, *Copper*, in threads often moulded to the quartz—4, *Orthoclase* in minute crystals planted on the prehnite, quartz and copper.

No. 27. SAME BED.—1, *Prehnite*, penetrated with copper threads—2, *Quartz* in prisms—3, *Chlorite-like mineral* mentioned in Nos. 20 and 21; here also it has eaten into the faces of the quartz crystals—4, *Analcite* crystals, much fractured and eaten away, and sometimes quite hollow.

No. 28. SAME BED.—1, *Prehnite* in places cavernous—2, *Quartz* in prisms in the cavities in the altered prehnite—3, *Orthoclase* crystals planted on the quartz.

No. 29. SAME BED.—1, *Prehnite*—2, *Copper* traversing the prehnite in the form of threads, etc., ending in crystals which adapt themselves to the crystalline surface of the prehnite.

No. 30. SAME BED.—1, *Prehnite*—2, *Analcite*—3, *Copper*, in flakes on the analcite—4, *Orthoclase; chlorite-like mineral.*

No. 31. SAME BED.—1, *Quartz* in prisms—2, *Orthoclase* crystals, planted on the quartz.

No. 32. SAME BED.—1, *Prehnite*—2, *Copper* in crystals whose under surfaces are moulded to the crystalline surface of the prehnite.

No. 33. HURON MINE.—On the amygdaloid containing smaller amygdules of delessite and quartz, lie:—1, *Laumontite*, a crystalline layer with projecting crystals—2, *Calcite* crystalized upon and wholly enveloping the laumontite crystals.

No. 34. WESTERNMOST ADIT ON THE "SOUTHSIDE." 1. *Analcite*, in opaque crystals $\frac{1}{8}$ to $\frac{1}{2}$ inch in diameter. 2. *Orthoclase* crystals planted on the analcite. (The rock containing this is chocolate-brown, and filled with small amygdules of 1st Laumontite, 2d Calcite).

No. 35. "RAGGED AMYGDALOID." ST. MARY'S. This is a soft brown amygdaloid with brown streak, in which the cavities have assumed the most irregular shapes and merge into each other in a manner which gives to the rock a highly brecciated appearance. The cavities are generally partially open at their wider points; and the minerals occupying them are chiefly the following, often accompanied by a white clay. On the rock lie, 1. *Analcite.* 2. *Orthoclase* crystals on the analcite. 3. *Calcite* over both the foregoing members.

No. 36. SAME BED. On the rock lies *Calcite. Orthoclase* crystals on the calcite.

No. 37. SAME BED. On the rock are scattered, 1. *Analcite* crystals. 2. *Calcite* on the analcite.

No. 38. SAME BED. 1. *Analcite* in large crystals; much altered. 2. *Orthoclase* crystals planted upon the outer surface of, and in cavities in, the analcite.

No. 39. PEWABIC COPPER-BEARING BED. On the amygdaloidal rock lies, 1, *Calcite; copper.* 2. *Datolite* in a granular mass incrusting the calcite crystals.

No. 40. SAME BED? 1. *Calcite* in scalenohedrons. 2. *Datolite*, a granular mass of microscopical crystals. Here the datolite has partially displaced the calcite; only the points of the crystals of the latter were exposed, all the rest being embedded in the younger datolite. These free-standing points remain perfect in glance and form, while wherever the calcite crystals are in contact with the datolite, their surfaces are roughened and perceptibly eaten into. The calcite crystals rest upon a granular mass of the same variety of datolite, which is perhaps the result of a displacement of calcite.

No. 41. "EVERGREEN BLUFF." 1. *Quartz* prism. 2. *Orthoclase* in minute crystals. 3. *Calcite* in simple and twin scalenohedrons.

No. 42. "AMYGDALOID" MINE. (Fissure vein). 1. *Copper.* 2. *Compact datolite.*

No. 43. SAME VEIN. 1. *Prehnite* in its characteristic form. 2. *Copper* conforming to the radiating cleavage-structure of the prehnite. 3. *Datolite*, compact.

No. 44. LOCALITY UNKNOWN. 1. *Prehnite* in its characteristic form. 2. *Quartz* in prisms on the prehnite. 3. *Analcite* crystals on the quartz. 4. *Orthoclase* crystals on the analcite.

No. 45. WESTERNMOST ADIT. "SOUTHSIDE." Small amygdules consist of, 1. *Laumontite.* 2. *Quartz* surrounded by the laumontite.

No. 46. MICHIGAN MINE (Fissure vein). On the veinstone, which is here a greenish-gray, hardened clay-like material with flakes of chlorite and copper, and which becomes brown and soft near the contact with No. 1, lies, 1. *Datolite* in a uniformly distributed layer $\frac{1}{10}$ of a line to 2 lines thick, with the free surface highly crystallized. The crystals are transparent and rose-colored from the presence of minute particles of copper. The datolite appears quite fresh, and the copper seems to be confined to it. 2. *Calcite*, four small slightly yellowish semi-transparent rhombohedrons, modified with steeper scalenohedron faces, lie upon the datolite. 3. *Orthoclase*, yellowish crystals, $\frac{1}{20}$ of an inch long, are scattered over the surface of the specimen, some lying upon the calcite and some upon the datolite.

No. 47. MANY LOCALITIES. 1. *Prehnite.* 2. *Delessite.* The prehnite which occurs as the solid filling of amygdaloidal cavities in the upper part of many beds, is subject to alteration to chlorite. It is very common to see the prehnite soft and green to a slight depth from the outer surface of the amygdule, without any line of separation between this portion and the hard center; and in the interior the prehnite often passes gradually into spots and flakes of chlorite. In these amygdules the prehnite is characterized by a radiating structure, starting from a single center. It is along these planes of radiation that the change begins. Every possible gradation is observable. The resulting product is sometimes a mass of foliated chlorite, but more generally it is an amygdule of compact chlorite, exhibiting in its fracture the same radiating structure as the prehnite.

No. 48. SHELDEN AND COLUMBIAN LOCATION. 1. *Prehnite* which is the general filling of the cavities in the upper part of the amygdaloid of this locality. 2. *Feldspar*, red. It is quite an exceptional occurrence in this neighborhood, and it is intimately associated with the prehnite in a manner that makes it seem to be pseudomorphous after it.

Crystals of epidote and of quartz occur on this feldspar, but the specimen gives no insight into their relation, as regard age, either to each other or to the feldspar as a secondary product.

No. 49. SOUTH PEWABIC MINE. In this bed a frequent form of the rock is a compact amygdaloid, of which 50 or 60 per cent of the volume consists of amygdules from the size of a pin-head to ⅛ inch in diameter. The matrix in a specimen before me is brown, and too hard to be scratched with a knife. The amygdules are sometimes of calcite, but more generally contain, 1. *Quartz*, clear and filling the cavity. 2. *Chlorite; copper*. The chlorite (apparently delessite) appears to displace the quartz; in some amygdules it merely penetrates the fissures of the quartz, giving to this a green color; in others nothing remains but a cavernous mass of quartz and chlorite usually well charged with copper; indeed the copper occurs here only with this chlorite.

The series to which this bed belongs is represented on the "Southside," and again on the St. Mary's, by amygdaloids which resemble this one in all essential particulars, except that the amygdules are there filled chiefly with laumontite, and are free from copper and nearly free from chlorite.

No. 50. "OSSIPEE AMYGDALOID." The rock is compact, spotted green and brown, and contains small *separate* amygdules of prehnite, quartz, epidote, calcite, chlorite. The chlorite appears as a destroyer of prehnite, quartz and calcite. A larger cavity shows the following succession: 1. *Prehnite;* a lining ⅛ to ⅛ inch thick, much altered and in places changed to chlorite. 2. *Orthoclase*, minute crystal. 3. *Epidote* on the feldspar.

No. 51. HURON MINE. In places, the Isle Royale copper-bearing bed consists largely of a light grayish-green, fine-grained rock of epidote and chlorite indurated with quartz; small, irregular cavities in this contain, 1. *Epidote;* crystalline lining ¼ inch thick. 2. *Quartz* filling the interior.

No. 52. SHELDEN AND COLUMBIAN MINE. In cavities in a brown and green amygdaloid lie, 1. *Quartz* in well shaped prisms. 2. *Calcite; Quartz.* This second quartz is in small and very much distorted crystals, which are often partially imbedded in the calcite, and are also often planted on the older quartz, from which they can be easily removed without fracture.

No. 53. HURON MINE. 1. *Quartz* with more or less crystalline structure. 2. *Copper* moulded on the quartz and filling cracks and interstices in it.

No. 54. RAGGED AMYGDALOID. ST. MARY'S. In the rock (see No. 35), some of the smaller cavities contain, 1. *Orthoclase* as a thin crystalline lining. 2. *Calcite* filling the interior. 3. *Chlorite-like mineral* penetrating and apparently replacing the calcite.

In a larger cavity occur the following:

No. 55. 1. *Analcite* crystals ½ inch to 2 inches in diameter, much reddened. 2. *Orthoclase;* small crystals on the analcite. 3. *Clay?* a soft white mineral, apparently the result of continued decomposition of the analcite under conditions unfavorable for the formation of new silicates as feldspar.

No. 56. "ANCIENT PIT" BED. DOUGLASS LOCATION. 1. *Epidote* forming a crystalline lining of a cavity. 2. *Quartz* filling the interior.

No. 57. SULPHURET (Fissure vein) HURON LOCATION. The vein (6–8 inches wide) consists of the following: 1. *Ankerite?* (crystalline, massive, white on fresh surface, but rusty-brown on exposed fractures) forming the member nearest the wall on each side. 2. *Quartz* in two symmetrical comby bands on the dolomite and in thin seams in the dolomite connected by cross-seams with the quartz-comb. 3. *Chalcocite*, black—bluish-black *with distinct cleavage.* It resembles the pseudomorphous chalcocite of the Lac la Belle mine. Bornite occurs sprinkled through the chalcocite in minute specks; in places it predominates, sometimes to the exclusion of the latter.

These sulphurets form the central member, and bunches of them are often surrounded by the older members, giving the "cockade" structure to the vein.

***Note.*—It is in another portion of this vein that the arseniurets, whitneyite and domeykite are found.**

I have attempted to bring the foregoing observations into the following tabular form for greater convenience of comparison. The table is unavoidably imperfect, owing to the necessary difficulties which arise in attempting to compare the successions of different localities. The detailed observations, however, will serve for a check upon the imperfections of the schedule.

COPPER AND CALCITE.—In many of the instances in which calcite crystals are found enclosing copper, it is difficult and

Capen Vein, --------	1	Laumontite	-----	Prehnite	-----	---	-----	Chlorite	Analcite	Calcite	----	----	------	----
Huron Mine,--------	2	Laumontite	-----	Prehnite	-----	---	-----	-------	------	---	----	----	------	----
Copper Falls Mine.*---	3	Laumontite	-----	------	-----	---	-----	-------	Analcite	---	----	----	------	----
“ “ “ *---	4	------	-----	------	-----	---	-----	-------	Apophyllite	---	Copper	----	Orthoclase	----
Bay State Mine.*-----	5	------	-----	Prehnite	Quartz	---	Copper	-------	------	---	----	----	------	----
Phœnix Mine,*-------	6	Laumontite	-----	------	Quartz	--	-----	Green-earth.	------	---	----	----	------	----
Bay State Mine,*-----	7	------	-----	------	Quartz	---	-----	-------	Apophyllite	Calcite	----	----	------	----
Bohemian Mine,*-----	8	------	-----	------	------	---	-----	-------	Analcite	---	Copper	----	Orthoclase	----
Amygdaloid Mine,----	9	------	-----	Prehnite	Quartz	---	-----	-------	Analcite	---	----	----	Orthoclase	----
Bay State Mine, ------	10	------	-----	------	-----	---	-----	-------	Analcite	---	----	----	Orthoclase	----
Amygdaloid Mine, ----	11	------	-----	Prehnite, Cu	-----	---	-----	-------	------	---	----	Datolite	------	----
“ “ ----	12	------	Calcite	Prehnite, Cu	-----	---	-----	-------	------	---	----	Datolite	------	----
Pewabic Lode, -------	13	Laumontite	-----	------	Quartz	---	Copper	Chlorite or Green-earth.	------	Calcite. Copper.	----	Datolite	------	----
“ “ -------	14	Laumontite	-----	------	Quartz	Calcite	Copper	Chlorite or Green-earth.	------	Calcite	----	----	Orthoclase	----
Alb. and Bost. “Ragged Amygd.” -----	15	------	-----	Prehnite	-----	---	-----	-------	------	---	----	----	Orthoclase	----
“Epidote Lode,” St. Mary's, ----------	16	------	-----	Prehnite	Quartz	---	-----	Chlorite or Green-earth.	Analcite	---	----	----	------	----
Amygd. Kearsarge, ---	17	------	-----	Prehnite	Quartz	---	-----	-------	------	---	----	----	------	----
Huron Mine.--------	18	------	-----	------	-----	---	-----	-------	Analcite	Calcite	----	----	------	----
Alb. & Bost. Amygd.--	19	------	-----	Prehnite	Quartz	---	-----	-------	------	---	----	----	Orthoclase	----
“ “ “ --	20	------	-----	Prehnite	Quartz	---	-----	Chlorite or Green-earth.	------	---	----	----	Orthoclase	Calcite
“ “ “ --	21	------	-----	------	Quartz	---	-----	Chlorite or Green-earth.	------	---	----	----	------	Calcite
“ “ “ --	22	------	-----	Prehnite	Quartz	---	-----	-------	------	---	----	----	Orthoclase	----
“ “ “ --	23	------	-----	Prehnite	Quartz, Cu	---	-----	-------	------	---	----	----	------	----
“ “ “ --	24	------	-----	Prehnite	Quartz	---	-----	-------	------	---	----	----	------	Calcite
“ “ “ --	25	------	-----	------	-----	---	-----	-------	Analcite	---	----	----	Calcite. Orthoclase.	---- ----
“ “ “ --	26	------	-----	Prehnite	Quartz, Cu	---	-----	-------	------	---	----	----	Orthoclase	----
“ “ “ --	27	------	-----	Prehnite	Quartz	---	-----	Chlorite or Green-earth.	Analcite	---	----	----	------	----
“ “ “ --	28	------	-----	Prehnite	Quartz	---	-----	-------	------	---	----	----	Orthoclase	----
“ “ “ --	29	------	-----	Prehnite, Cu	-----	---	-----	-------	------	---	----	----	------	----

Alb. & Bost. Amygd.	30	------	-----	Prehnite	-----	---	-----	-------	Analcite	---	Copper	----	Green-earth or Chlorite. Orthoclase.	----
" " "	31	------	-----	------	Quartz	---	-----	-------	------	---	----	----	Orthoclase	----
" " "	32	------	-----	Prehnite, Cu	-----	---	-----	-------	------	---	----	----	------	----
Huron Mine,	33	Laumontite	Calcite	------	-----	---	-----	-------	------	---	----	----	------	----
"Southside,"	34	------	-----	------	-----	---	-----	-------	Analcite	---	----	----	Orthoclase	----
"	"	Laumontite	Calcite	------	-----	---	-----	-------	------	---	----	----	------	----
"Ragged Amygdaloid,"	35	------	-----	------	-----	---	-----	-------	Analcite	---	----	----	Orthoclase	Calcite
" "	36	------	-----	------	-----	---	-----	-------	------	Calcite	----	----	Orthoclase	----
" "	37	------	-----	------	-----	---	-----	-------	Analcite	Calcite	----	----	------	----
" "	38	------	-----	------	-----	---	-----	-------	Analcite	---	----	----	Orthoclase	----
Pewabic Bed,	39	------	-----	------	-----	---	-----	-------	------	Calcite	Copper	Datolite	------	----
" "	40	------	-----	------	-----	---	-----	-------	------	Calcite	----	Datolite	------	----
Evergreen Bluff,	41	------	-----	------	Quartz	---	-----	-------	------	---	----	----	Orthoclase	Calcite
Amygdaloid Mine,	42	------	-----	------	-----	---	-----	-------	------	---	Copper	Datolite	------	----
" "	43	------	-----	Prehnite	-----	---	-----	-------	------	---	Copper	Datolite	------	----
Unknown locality,	44	------	-----	Prehnite	Quartz	---	-----	-------	Analcite	---	----	----	Orthoclase	----
"Southside,"	45	Laumontite	-----	------	Quartz	---	-----	-------	------	---	----	----	------	----
Michigan Mine,	46	------	-----	------	-----	---	-----	-------	------	---	Datolite	Calcite	Orthoclase	----
Many localities,	47	------	-----	Prehnite	-----	Delessite		-------	------	---	----	----	------	----
Shelden & Columbian,	48	------	-----	Prehnite	-----	---	-----	-------	------	---	----	----	Feldspar	----
South Pewabic Mine,	49	------	-----	------	Quartz	- -	-----	Chlorite or Green-earth. Copper.	------	---	----	----	------	----
Ossipee Amygdaloid,	50	------	-----	Prehnite	-----	---	-----	-------	------	---	----	----	Orthoclase	Epidote
Huron Mine,	51	------	Epidote	------	Quartz	---	-----	-------	------	---	----	----	------	----
Shelden & Columbian,	52	------	-----	------	Quartz	Calcite. Quartz.	-----	-------	------	---	----	----	------	----
Huron Mine,	53	------	-----	------	Quartz	---	Copper	-------	------	---	----	----	------	----
Ragged Amygdaloid,	54	------	-----	------	-----	---	-----	-------	------	---	----	----	Orthoclase	Calcite Chlorite Clay
" "	55	------	-----	------	-----	---	-----	-------	Analcite	---	----	----	------	
"Ancient Pit" Bed, Douglass,	56	------	Epidote	------	Quartz	---	-----	-------	------	---	----	----	Orthoclase	----
'Sulphuret V'n,' Huron,	57	------	Ankerite?	------	Quartz	---	Bornite. Chalcocite	-------	------	---	----	----	------	----

often impossible to distinguish as to the relative ages of the two. But specimens in my collection offer conclusive proof that each of the following cases occur.

I.—*The copper was present before the calcite began to form, and became enclosed in the growing crystal.*

In this case the copper and its associated minerals generally form the basis on which the calcite rests, and the crystals of the latter exhibit entering faces wherever the surface of the crystal is in contact with the copper; it should seem to indicate an effort at those points to crystallize free from the foreign substance, by forming separate individuals. But on the finished crystal the traces of this tendency is visible, generally, only in the comparatively very small entering faces at the contact with the copper.

In this way calcite crystals, formed in a cavernous mass of copper, are intersected internally by a perfect net-work of thin plates of the metal, and yet preserve their cleavage unaffected; but wherever the copper comes in contact with the surface of the crystal, the small entering faces are present.

II.—*The crystal of calcite was partly formed, then became incrusted with copper, and was finished by a new growth of calcite over the metallic film.*

A most remarkable instance of this case is that of a crystal about 2 inches long—a steep scalenohedron—with a basal termination of about 1 square inch surface. At this stage of its growth it was covered, over nearly the whole surface, with a thin coating of copper. The basal termination on scalenohedrons of calcite is as rare on Lake Superior as elsewhere, and in the few instances where I have seen it, it lacks the polish which indicates perfect growth. The tendency to complete the point of the scalenohedron is well shown on this specimen; over the partially copper-coated basal plane there are scattered a large number of perfectly pointed scalenohedrons—two or three of these are ⅛ to ½ inch high—and others are scattered over the side-faces. All of these younger crystals are arranged in perfect uniformity with the plan of the underlying, older individual.

Those portions of the surface on which the copper-coating is perfect have no younger calcite crystals; these occur where the metallic film is thinnest and more or less perforated.

The copper is not confined absolutely to the surface of the crystal on which it lies; it penetrates to a slight distance along the cleavage-planes, and the result is an exceedingly delicate treiculation on its under surface. The calcites which are planted on the copper contain brilliant particles of the metals swimming, if one may use the word, in the interior of the crystals; and these are so disposed as to lead to the idea that throughout the growth of the younger crystals they had to contend with the continued deposition of the metal. Thus one of the new scalenohedrons, after growing to the height of $\frac{1}{4}$ inch, was, like the underlying one, also ended with a basal termination, on which again smaller new and well pointed individuals were built up.

III.—*The copper has entered the calcite crystal since its growth was finished.*

A specimen, in my collection, illustrates this remarkably well. It is a cleavage-rhombohedron of opaque calcite, traversed by intersecting sheets of copper, which are wholly independent of the cleavage planes. On detaching the copper from the calcite, the surface of the latter appears rough; it is a fracture oblique to the cleavage, and the face of the fracture is formed by countless corners, or solid angles, of minute cleavage-rhombohedrons, as is fully proved by the reflexion of the light. The copper-sheets, which are about $\frac{1}{16}$ inch thick, reproduce this very completely.

Another very remarkable specimen is from the cement of the Albany and Boston conglomerate. It is about 1 inch in diameter, and consists of opaque white calcite. The continuity of the cleavage shows it to be a single individual, though it passes on the edges without any sharp demarkation into the common cement of the conglomerate. This calcite is traversed by continuous sheets of copper $\frac{1}{200}$ to $\frac{1}{16}$ inch thick, which are perfectly straight. These sheets are parallel to several planes, (nearly all of which are independent of the cleavage) and intersect each other. In each of the sets thus formed the sheets are perfectly parallel, and are separated by plates of calcite, which are in places as thin as the copper itself. Where three such sets intersect each other, the resulting solid appears composed of concentrically arranged laminæ of copper and calcite. In some parts of the specimen the copper predominated over the calcite. Wherever the faces of the copper laminæ are exposed, they are marked with a delicate, reticulated tracery, indicating the lines of intersection of the sheet with the cleavage planes of the crystal. The cement in the vicinity of the calcite is impregnated with copper; in places it is almost wholly replaced by the metal in the fine granular condition called "brick copper," and into this the laminæ of metal extend, without break, from the calcite. This specimen is really a pseudomorph of copper after calcite.

Copper and Silver.—It is a well known fact that these two metals occur in the metallic state, in the Lake Superior deposits, in the most intimate contact with each other, and yet without being mutually alloyed. Even at the contact they are not absolutely joined together, for after rolling out a piece of copper containing spots of silver, the two metals become more or less separated, and may often be readily detached from each other. I have not been able to obtain any material that would throw light upon the relative ages of the two metals.

[To be continued.]

Art. XXXIV.—*On Photographing Histological Preparations by Sunlight;* by J. J. Woodward, Asst. Surgeon U. S. Army. Report to Surgeon General J. K. Barnes, U. S. Army. Washington, June 9, 1871.

In January, 1870, I had the honor to submit to you a report in which I detailed the results of a series of experiments, which showed the superiority of the electric and magnesium lights over sunlight, as heretofore employed, for the production of photo-micrographs of the soft tissues. In June of the same year I made a report in which I showed that similar results could be obtained with the oxy-calcium light. With these various artificial sources of light, I obtained pictures which appeared to me to be "clearer and better defined than any photographs of similar objects I had hitherto seen produced by sunlight."

So many cloudless days are offered to the photographer in Washington, that I could not but regret these results; yet they appeared to be final at the time of writing. During the last few months, however, I have found improved methods of using the light of the sun for photographing the soft tissues, and have arrived at results which must materially modify the conclusions of my former reports.

Not that I have anything to withdraw from the opinions I have expressed, as to the certainty and success attending the use of artificial lights for the purpose named, but I have much to add with regard to the most advantageous methods of using the light of the sun for obtaining satisfactory pictures of tissue preparations, and such other objects as approximate them in optical characteristics.

If a well made preparation of some normal tissue, or of some pathological growth, stained with carmine, silver, or gold, and mounted temporarily in glycerine, or permanently in Canada balsam, be illuminated by white cloud illumination, or by lamp light, and found to be all that could be desired, it will nevertheless appear very unsatisfactory if illuminated by the direct rays of the sun.

The eye glancing through the tube of the instrument, dazzled by the powerful light, discerns amidst the blaze, innumerable colored rings, produced by diffraction and interference which disturb the normal appearances of the preparation and render its interpretation impossible.

If the image be received upon a white screen similar phenomena obtrude themselves, destroying the clearness of the picture, though no longer injuriously affecting the eye; and if monochromatic light is employed, although the disorderly play of color disappears, black rings and lines of the most manifold character and direction take their place. Pictures produced under these circumstances are of course quite useless, and the difficulty occurs not merely in the case of tissue preparations, but in a very large number of other objects.

To escape these disagreeable results, it has heretofore been the practice to pass the solar pencil through a piece of ground glass. This plan is recommended in all the treatises on photo-micrography, and has hitherto been employed in the solar work done at the Army Medical Museum. The method is effectual in getting rid of the diffraction and interference phenomena complained of; an image is obtained which is clear and satisfactory to the eye looking down the tube, but it appears very weak on the screen, and is sadly deficient in contrast. These faults are reproduced in photographs of objects thus illuminated, and, moreover, the time of exposure is enormously increased. Such pictures are decidedly inferior to those which can be obtained by the magnesium, or even by the calcium light, with which no ground glass is used.

I desire now to call your attention to the fact that in the course of some recent experiments, I have ascertained that the diffraction and interference phenomena above complained of, may be prevented by the use of a suitable condensing lens, even better than by the ground glass; that by this plan the exposure may be greatly diminished, say from three minutes for five hundred diameters, to a fraction of a second, and that the resulting pictures are not merely quite as free from diffraction and interference phenomena as the best that can be obtained when the ground glass is used, but are characterized by greater contrast and superior sharpness of definition.

The details of my new method are as follow: The microscope being placed on a shelf at the window of the dark room, and its body made horizontal, the achromatic condenser is illuminated by a solar pencil reflected from a heliostat upon a moveable mirror outside the shutter and thence into the dark room, precisely as described in my original paper on photo-micrography.*

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* This Journ., II, vol. xlii, p. 189, Sept., 1866.

No ground glass is used, but instead a lens mounted in a suitable tube is fixed in the opening of the shutter through which the solar pencil enters. This lens is an achromatic combination about two inches in transverse diameter and of about ten inches focal length. It is placed at such a distance from the achromatic condenser that the solar rays are brought to a focus and begin again to diverge before they reach the lowest glass of the achromatic condenser.

For anatomical preparations requiring for their display from two to five hundred diameters, I use an $\frac{1}{8}$th of an inch objective, without an eyepiece, obtaining the precise power desired by variations in the distance of the sensitive plate from the stage of the instrument. I have lately given the preference to immersion objectives, the corrections of which I find are generally well suited to photographic requirements.

Now with an 1-8th objective and the arrangement above described, the field is so brilliantly illuminated that the eye cannot safely be permitted to look down the tube. The image is therefore received on a piece of white card-board, and sitting by the microscope to make the adjustment, I view the card with both eyes precisely as in the case of the ordinary solar microscope. With these arrangements, the card-board placed from two to four feet from the stage of the microscope is sufficiently well illuminated to permit distinct vision, even when objectives of the shortest focus are used and powers of five to ten thousand diameters obtained. While the object is thus seen on the white screen in its natural colors, the cover corrections, focussing, management of the achromatic condenser, and selection of the portion of the preparation to be photographed, are readily managed. When all is satisfactory, I insert an ammonio-sulphate cell between the large lens and the achromatic condenser, and draw down the velvet hood which prevents leakage of light from about the microscope into the dark room; then going to the plate holder, I make the final focussing in the usual way on the ground glass, or on plate glass with the help of a focussing glass, according to the nature of the object.

With powers of five hundred diameters or less, I at first experienced some difficulty in giving the right exposure; for as the time required was but a fraction of a second, it was a matter of some difficulty to regulate it with precision. At length I succeeded by arranging a sliding shutter, with a transverse slit of variable width, so adjusted as to fall with its own weight before the tube of the microscope, the exposure being made during the passage, and the time of exposure regulated by the width given to the slit.

Of course it occurred to me that for such short exposures the heliostat might be dispensed with, and I found on trial without it that a large right-angled prism used in the position of total reflection, or even an ordinary mirror gave excellent results; the exposures being even shorter than when the heliostat was used, since there was but a single reflection. I could not satisfy myself, however, that the quality of the pictures differed from those obtained with the help of the heliostat, except perhaps that in certain cases the prism seemed to offer advantages which will be referred to hereafter. Under these circumstances the heliostat appears desirable for ordinary use, since the solar pencil being thrown in a constant direction, the trouble of adjusting the illumination of a series of objects is considerably diminished; but I have convinced myself by trial that equally good pictures can be produced without it, even with very high powers, a circumstance of considerable interest where motives of economy preclude the microscopist from procuring this convenient instrument

A few remarks with regard to certain points in the procedure above sketched seem called for.

First, with regard to the selection of objectives suitable for photographic work of this kind. The power of the objective to be used will depend of course upon the details it is desired to display. I find it best to use the naked objective without eye-piece or amplifier, and not as a rule to fix the sensitive plate more than three or four feet from the stage of the microscope. An 1-8th objective may be conveniently employed to obtain powers of from two to five or six hundred diameters, a 1-16th for higher powers up to twelve or fifteen hundred diameters. Suitable amplifiers or even eye-pieces may be used in either case, with great increase of the magnifying power, and often with admirable scenic effect, but there is always a certain loss of definition. Still such amplifications may sometimes be advantageously resorted to, especially in the case of objects which present very minute details; for in these cases the paper prints will often lose many of the fine details of the negative, and the loss of definition incurred by the amplifier or eye-piece is not unfrequently less than that encountered in attempting to transfer to paper a negative prepared with insufficient magnifying power. Thus far my experience is decidedly in favor of using sufficient power in the first instance, rather than attempting to enlarge negatives taken with less power.

The objective selected should of course be unexceptional in defining power, and should always be specially corrected for photography. It has been erroneously stated by Moitessier,* that if an ammonio-sulphate or other blue cell be interposed in the solar pencil, all special corrections of the objective may be dispensed with. This proposition, which has been adopted by many other writers, appears plausible, but a little consideration will show it to be quite erroneous.

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* La Photographie Appliquée aux Recherches Micrographiques, par A. Moitessier, Paris, 1866, p. 180 et seq.

Every one knows that a good objective must be free from spherical, as well as from chromatic, aberration. Of course the use of monochromatic light disposes of the chromatic trouble. Not so with the spherical aberration. Now this aberration, like the chromatic, is corrected mainly by the just combination of flint with crown glass in the several pairs which constitute the objective. If these are so adjusted as to correct spherical aberration as nearly as possible for white light, they will no longer do so for light which has passed through the ammonio-sulphate of copper. Until objective makers take this fairly into consideration, the microscopist who desires to photograph what he sees is left to a happy chance in the selection of his objectives. For even those makers who profess to prepare objectives "specially corrected for photography" do not deal any too well with the problem. If they would test their objectives, while making them, with violet light, we should have better results; for with such illumination the eye can see all that photography can execute, and no more.

But this circumstance fortunately enables the microscopist to select from the objectives in the market those which are suitable for photography. It is only necessary to test their performance when illuminated by sunlight, which has passed through an ammonio-sulphate cell. Now it fortunately happens that the high power immersion objectives of certain makers, especially those of Powell & Lealand, possess very nearly the corrections which theory would indicate as best adapted for photographic use. Nevertheless it can hardly be doubted that even these objectives could be greatly improved if the makers would take into consideration the principles involved in the foregoing remarks.

A second point, which deserves attention, is the use of the large condensing lens above described. This lens, it will be understood, corresponds with the large condensing lens of the ordinary solar microscope, while the achromatic condenser takes the place of the so-called field glass of the same instrument. It has already been mentioned that this lens should be placed at such a distance from the achromatic condenser that the solar rays may be brought to a focus, and begin again to diverge before they reach its lowest glass. A different arrangement is usually employed in the solar microscope, the field glass being placed at such a distance from the first condenser that the solar rays impinge upon it before they come to a focus. As a consequence, the convergent pencils proceeding from the first lens are still further converged by the field glass, and a burning focus of heat, as well as of light, is produced, which is damagng to the preparation as well as to the balsam cement of the objectives used. If, however, the rays from the first lens are permitted to come to a focus and to begin to diverge before striking the second, this latter can readily be adjusted so as to bring the illuminating rays to a handsome focus, while the heat ays, after passing the second lens, become parallel or even divergent according to the position of the achromatic condenser, and all trouble from the solar heat is thus completely avoided. So successfully may this separation be effected, indeed, that I have frequently obtained light enough to give distinct vision and admirable definition on the card-board screen with five thousand linear diameters or even higher powers (obtained by the immersion 1-16th, an amplifier, and four feet or greater disance), while the heat was so slight that the drop of water used with the immersion lens did not require renewal oftener than about once in two hours.

I had employed this device for several months, and supposed it to be quite novel, when I read the paper of the late distinguished President of the Royal Microscopical Society of London, the Rev. J. B. Reade, "On the separation of the rays of heat from the rays of light in solar and oxy-hydrogen-gas microscopes."* I learned from that article that Mr. Reade had devised this very plan as an improvement to the solar microscope as long ago as 1836. The advantages attained may be stated in his own lucid words.

"It is evident by this arrangement of lenses we convert the parallel solar beam first of all into a cone of light-giving rays within a cone of heat-giving rays, and the principal focus of heat is farther from the condensing lens than the principal focus of light. But after these rays cross the axis we have, conversely, an equal and opposite cone of heat-giving rays within a cone of light-giving rays, and a plano-convex lens or hemisphere, if placed in this second cone at the distance of its own focal length from the principal focus of heat, will be at a distance greater than its focal length from the principal focus of light; and, consequently, the rays of heat, after passing through this lens, will become parallel, while the rays of light converge to a second focus. I have approximately measured the heating power of the thermal rays of the second cone when rendered parallel by the plano-convex lens, and I found, in the month of December, that the mercury in a sensitive thermometer, when placed in the second focus, did not reach 90° Fah., while at the same time the heat at the focus of the first cone was sufficient to discharge gunpowder."

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* The British Journal of Photography, Dec. 16, 1870, p. 590.

Mr. Reade appears to have experimented with low power objectives only, for he speaks merely of such preparations as the head of a flea. He therefore succeeded very well by using a single lens in his field glass. With such powers as the immersion $\frac{1}{8}$th and $\frac{1}{16}$th, I find it better to use an ordinary achromatic condenser instead. The principles involved are of course identical. For the first condenser also, I have been using an achromatic combination of the dimensions and focal length above mentioned, taken from the back of an ordinary photographic protrait tube; but I am not sure that a simple plano-convex lens of the requisite diameter and focal length would not answer every purpose.

The introduction of the ammonio-sulphate cell would of itself prevent the passage of most of the heat rays falling upon it, but if this were the only means of excluding them, it would not be possible to focus primarily with white light on the card-board screen in the manner which I have found so convenient.

I have already stated that the time of exposure required for the production of pictures magnified five hundred diameters or less, was a fraction of a second. With higher powers it increases, varying with the management of the achromatic condenser. For four thousand diameters I have sometimes needed as much as twenty-five seconds.

So long as the exposure is greater than a second, the requisite time may readily be given with a piece of velvet, or a card-board screen held in the hand. For shorter exposures some mechanical contrivance is indispensable. That alluded to above seems to answer every purpose, and is arranged as follows: A wooden screen is fixed between the microscope and the sensitive plate, as close as convenient to the microscope. To prevent side lights reaching the plate, the screen is connected with the window shutter by velvet curtains, which can be turned aside to manipulate the instrument, and be let down at the proper time. A circular hole, three inches in diameter, is made in the screen opposite the tube of the microscope for the transmission of the image. In front of this a light shutter slides loosely up and down, held in place by a cleat of wood on each side, the design being to permit the shutter to fall edge foremost with as little friction as possible. The shutter may be made of thin metal, of wood, or even of card-board. I am using one of pine wood the $\frac{1}{16}$th of an inch thick—I have used one of card-board with equal success. In the shutter is an opening, three inches wide by ten long, covered with a card-board slide, by means of which any width of slit, from a fraction of an inch to ten inches, can be given. The part of the shutter below the slit closes the aperture through which the image passes when the shutter is fixed in place before the exposure is made. On drawing a wooden trigger the shutter is started on its fall, which is arrested by a piece of string of suitable length. The exposure has now been made, but the aperture through which the image passes is again closed, this time by the part of the shutter above the slit. The shutter is so light that the jar caused by the sudden arrest of its motion by the string is too trifling to do any damage to the microscopic apparatus, and as it occurs after the exposure is over it cannot affect the image. I find that if, when the shutter is started, the lower edge of the slit is an inch above the aperture through which the image passes, a convenient velocity is attained for a magnifying power of two to five hundred diameters, arranged as I have described. For still shorter exposures, necessitated by lower powers or other circumstances, it would be best to start the shutter from a greater height, which would give greater velocity to the passage of the slit, and any available fraction of time desired might thus conveniently be obtained. The whole arrangement is inexpensive, and may be manufactured in a few hours by any one, out of a deal board, a few pieces of card-board and a yard or two of cotton velvet.

Of course the fractional measures of time obtained in this way are not absolute, since the friction must be variable, unless the apparatus were made in a more costly manner of metal. But I have found that the variations thus introduced are so small that they may be disregarded, and that while the starting point remains the same, the width of the slit in the falling shutter indicates fractions of time which may confidently be counted upon to give proportional photographic results.

The next subject for remark is the arrangement employed when the heliostat is dispensed with.

For this purpose the contrivance usually employed for the solar microscope answers very well. A circular disc of brass, with toothed edges, is let into a square plate of the same metal, and is turned by a small toothed wheel, to which a suitable button or milled head is attached. Through the center of the disc passes a tube six or eight inches long and two inches in diameter, the outer extremity of which is fitted to receive the large condensing lens. Just below this tube an arm is firmly attached to the outer surface of the disc for the purpose of carrying the mirror or right-angled prism, to which any desired inclination can be given by a rod passing through the disc by the side of the tube. The whole arrangement is quite like the similar parts of the ordinary solar microscope, and hence needs no minute description; it is fitted into a window shutter, which must of course face to the south, and the room being darkened, the motions of the mirror or prism can readily be controlled from within. If the condensing lens is used, I do not think any material advantage can be obtained from the prism, and its expense is a decided objection. In the winter season, in this latitude, a prism of over five inches hypothenuse is required, and its cost is a serious item. An ordinary glass mirror answers, I think, quite as well for the tissues and most other purposes. There are, however, certain objects, such as the Pleurosigmata and some other diatoms, the Nobert's test-plate, and the scales of certain insects, for which the condensing lens is unnecessary. The achromatic condenser, illuminated by a parallel solar pencil, answers better in these cases, and if it is properly managed no diffraction or interference phenomena are produced. I am satisfied that in such cases the pure parallel pencil obtained from the prism gives better definition to the image than can be obtained by the double pencil reflected from an ordinary glass mirror. A mirror silvered on the reflecting surface would, I suppose, answer the same purpose; but such mirrors are not permanent, and are troublesome to keep in order while they last. Moreover, if the prism is used only for this purpose, a very small and cheap one will answer, since a pencil half an inch in diameter is all that is required. Such a small right-angled prism is furnished with most large microscopes, and can readily be mounted outside the brass disc so as to answer the special purpose indicated. For all those objects which require the large condensing lens to avoid diffraction and interference, a common glass mirror will answer well enough. For lower powers than two hundred diameters, however, the ordinary mirror will often be found to reflect too much light, and the image on the card-board screen will be found too brilliant to be conveniently observed for any length of time. In such cases a piece of plain unsilvered plate glass may be substituted for the mirror. The greater portion of the solar light passes through it and is lost, but enough is reflected to make pictures of four hundred diameters in from two to three seconds exposure, and these pictures have all the qualities of those made with ordinary mirrors. I have tried instead to diminish the light by absorbing a part, using for this purpose an ammonio-sulphate cell of considerable thickness, but find that this plan diminishes the contrast and definition of the image, which is not the case when a mirror of simple plate glass is used as above described.

With regard to the management of the plate-holder, the apparatus for focussing, and other accessory arrangements, I need only say that I employ for the solar light the same simple plan which I have described in full in my reports on the use of artificial lights in photo-micrography.

Since making the experiments which have led to the foregoing results, I have modified my method of dealing with the electric light in photographing the tissues. I first render the divergent pencil proceeding from the carbon points as nearly parallel as possible by means of the condenser, usually supplied with electric lamps for this purpose, and then introduce into the parallel pencil, instead of a ground glass, the very same condensing lens described above for the process with solar light. The image is received primarily on a card-board screen, and the remaining details do not differ from what has been related above. The time of exposure does not exceed a single second for four hundred diameters, and the sharpness of the pictures exceeds any of my former results. Indeed, with this new arrangement, I must say that the electric light appears to me to retain the apparent superiority over sunlight, remarked in my paper on the use of this method of illumination in photo-micrography, at least in the case of all those objects which in themselves possess but little contrast. For well made tissue preparations, however, I find the best work I can do with the electric light so similar to the best attainable by sunlight, used as above described, that I should rarely take the trouble to set up the battery and work the electric lamp, unless it was desirable to work at night or in unfavorable weather.

[The memoir is accompained by photographic plates of tissues, magnified 400 to 500 diameters, as examples of the results obtained in the manner described, and concludes with description of the preparations.]

ART. XXXV.—*Barometrical Measurements in Ecuador;* by W. REISS and A. STÜBEL. Translated from the Spanish by Professor ORTON, Vassar College.

[THE following is an abstract of the principal altitudes near Quito, as determined by the able North German Expedition in 1870–1. Schmidt's value of the *vara*, given below, differs from the standard in the U. S. Office of Weights and Measures by — ·0015 meter. I have reduced the meters to English feet. It is remarkable that every successive measurement of the Quitonian Andes gives a reduced elevation. Thus: altitude of Quito by Humboldt, 9570; Orton, 9520; Reiss and Stübel, 9350;—of Panecillo by Humboldt, 10,244; Orton, 10,101; R. and S., 10,006;—of Pichincha by Humboldt, 15,922; Orton, 15,827; R. and S., 15,704;—of the crater by Wisse and Moreno, 13,600; Orton, 13,300; R. and S., 13,175.]

NOTE.—The altitudes are calculated in meters above the level of the sea, one meter equaling 1·1963 Spanish vara. The greater part of the observations were made with the barometer; but trig onometrical measurements were taken of some notable points. The letters B and T indicate these different means, and the numbers show the times of observations. As this work is provisional, the authors reserve the privilege of making corrections in the future, which, however, will be insignificant.

Place.	Altitude.		Method.
	Meters.	Feet.	
Tulcan, plaza (northern frontier),	2,977	9,767	1 B.
Chota bridge,	1,532	5,026	1 “
Isambal, foot of Yanaurcu,	4,041	13,257	3 “
Top of Yanaurcu,	4,556	14,947	2 “
El Fuyafuya, north summit,	4,294	14,087	2 “
“ south “	4,279	14,038	T.
Caricocha,	3,711	12,174	“
Tabacundo,	2,889	9,478	1 B.
Salinas, plaza,	1,639	5,377	3 “
Hatuntaqui, plaza,	2,407	7,897	2 “
Cotacachi, plaza,	2,453	8,048	24 “
Otovalo, plaza,	2,581	8,468	1 “
Hacienda of Cuicocha,	2,747	9,012	2 “
Border of the Lake Cuicocha,	3,118	10,229	T.
Top of Cotacachi, S.E. point,	4,960	16,272	“
“ “ N.W. “	4,966	16,291	“
“ “ N. “	4,829	15,842	“
Snow-limit on Cotacachi, S.W. side,	4,620	15,157	“
“ “ “ E. “	4,694	15,399	“
San Pablo, plaza,	2,726	8,943	3 B.
“ “ lake,	2,697	8,848	2 “
Top of Cusin,	4,012	13,162	2 “
La Esperanza, plaza,	2,344	7,690	16 “
Top of Curilche,	3,882	12,735	2 “
Lake within the crater,	3,801	12,470	2 “
Top of Cerro Cunru,	3,338	10,950	2 “
Lake in the crater,	3,317	10,882	1 “
Yaguarcocha,	2,253	7,391	4 “
Ibarra, plaza,	2,225	7,300	4 “
Imanta, “	2,422	7,946	2 “
Peguche, hacienda,	2,556	8,385	3 “
Guaillabamba, pueblo,	2,106	6,909	3 “
Alchipichi bridge,	1,719	5,639	2 “
Pomasqui, plaza,	2,507	8,225	2 “
Cotocollao, “	2,802	9,193	4 “
Perucho, “	1,830	6,004	3 “
Colicalí, pueblo,	2,792	9,160	2 “
Frutillas,	3,133	10,278	2 “
Mindo, hacienda of San Vicente,	1,264	4,147	16 “
El Pondoña, N.E. summit,	2,940	9,645	1 “
Pailon,	2,985	9,793	1 “
Junction of Rio Blanco with Rio del Volcan,	2,078	6,817	7 “
Hacienda of San José in Lloa,	3,091	10,140	26 “
Top of Rucu-Pichincha,	4,737	15,540	T

Place.	Altitude, Meters.	Altitude, Feet.	Method.
Cundurguachana,	4,090	13,254	1 B.
Top of Guagua-Pichincha,	4,787	15,704	T.
Bottom of the crater,	4,016	13,175	1 B.
Top of the mound in the crater,	4,087	13,408	1 "
Top of Panecillo,	3,050	10,006	2 "
Machángara, hacienda de las Monjas,	2,648	8,687	1 "
Bridge of Guápulo,	2,545	8,349	1 "
Church "	2,690	8,825	2 "
Tumbaco, plaza,	2,390	7,841	3 "
Puembo, "	2,484	8,149	2 "
Hacienda of Guachalá,	2,801	9,189	4 "
Cayambe, pueblo,	2,852	9,357	2 "
Top of Atacazo, edge of crater,	4,539	14,891	2 "
Arenal within crater,	4,242	13,916	2 "
Tambillo, tambo,	2,802	9,193	7 "
Aloac, pueblo,	2,922	9,586	2 "
Top of Corazon,	4,787	15,704	2 "
Machachi, tambo,	2,935	9,629	1 "
Gallocantana peak on Rumiñagui,	3,839	12,594	2 "
Bottom of the Caldera,	3,755	12,319	1 "
Peak between Capacocha and Sachacocha,	4,192	13,752	1 "
Hacienda of Pedregal,	3,531	11,584	1 "
Top of Pasochoa,	4,255	13,959	2 "
" Ilaló,	3,161	10,370	2 "
Alangasí, plaza,	2,587	8,487	1 "
Hacienda of Sñr. Jijon, Chillo,	2,518	8,261	1 "

Art. XXXVI.—*Inaugural Address before the British Association at Edinburgh, August 2d;* by Sir William Thompson, President of the Association.

Kew Observatory.

* * * One of the most valuable services to science which the British Association has performed has been the establishment, and the twenty-nine years maintenance, of its observatory. The Royal Meteorological Observatory of Kew was built originally for a sovereign of England who was a zealous amateur of astronomy. George the Third used continually to repair to it when any celestial phenomenon of peculiar interest was to be seen: and a manuscript book still exists filled with observations written into it by his own hand. After the building had been many years unused, it was granted, in the year 1842, by the Commissioners of her Majesty's Woods and Forests, on application of Sir Edward Sabine, for the purpose of continuing observations (from which he had already deduced important results) regarding the vibration of a pendulum

in various gases, and for the purpose of promoting pendulum observations in all parts of the world. The Government granted only the building—no funds for carrying on the work to be done in it. The Royal Society was unable to undertake the maintenance of such an observatory; but, happily for science, the zeal of individual fellows of the Royal Society and members of the British Association gave the initial impulse, supplied the necessary initial funds, and recommended their new institution successfully to the fostering care of the British Association. The work of the Kew Observatory has, from the commencement, been conducted under the direction of a committee of the British Association: and annual grants from the funds of the Association have been made toward defraying its expenses up to the present time. To the initial object of pendulum research was added continuous observations of the phenomena of meteorology and terrestrial magnetism, and the construction and verification of thermometers, barometers, and magnetometers designed for accurate measurement. The magnificent services which it has rendered to science are so well known that any statement of them which I could attempt on the present occasion would be superfluous. Their value is due in a great measure to the indefatigable zeal and the great ability of two Scotchmen, both from Edinburgh, who successfully held the office of Superintendent of the Obsertory of the British Association—Mr. Welsh for nine years, until his death in 1859, and Dr. Balfour Stewart from then until the present time. Fruits of their labors are to be found all through our volumes of Reports for these twenty-one years.

The institution now enters on a new stage of its existence. The noble liberality of a private benefactor, one who has labored for its welfare with self-sacrificing devotion unintermittingly from within a few years of its creation, has given it a permanent independence, under the general management of a committee of the Royal Society. Mr. Gassiot's gift of 10,000*l.* secures the continuance at Kew of the regular operation of the self-recording instruments for observing the phenomena of terrestrial magnetism and meteorology, without the necessity for further support from the British Association.

Physical Observatories and Laboratories.

The success of the Kew Magnetic and Meteorological Observatory affords an example of the great gain to be earned for science by the foundation of physical observatories and laboratories for experimental research, to be conducted by qualified persons, whose duties should be, not teaching, but experimenting. Whether we look to the honor of England, as a nation which ought always to be the foremost in promoting physical science, or to those vast economical advantages which must accrue from such establishments, we cannot but feel that experimental research ought to be made with us an object of national concern, and not left, as hitherto, exclusively to the private enterprise of self-sacrificing amateurs, and the necessarily inconsecutive action of our present governmental departments and of casual committees. The Council of the Royal Society of Edinburgh has moved for this object in a memorial presented by them to the Royal Commision on Scientific Education and the Advancement of Science. The Continent of Europe is referred to for an example, to be followed with advantage in this country, in the following words:—

"On the continent there exist certain institutions, fitted with instruments, apparatus, chemicals, and other appliances, which are meant to be, and which are made, available to men of science, to enable them, at a moderate cost, to pursue original researches."

This statement is fully corroborated by information, on good authority, which I have received from Germany, to the effect that in Prussia "every university, every polytechnical academy, every industrial school (*Realschule* and *Gewerbeschule*), most of the grammer-schools, in a word, nearly all the schools superior in rank to the elementary schools of the common people, are supplied with chemical laboratories and a collection of philosophical instruments and apparatus, access to which is most liberally granted by the directors of those schools, or the teachers of the respective disciplines, to any person qualified, for *scientific experiments.* In consequence, though there exist no particular institutions like those mentioned in the memorial, there will scarcely be found a town exceeding 5,000 inhabitants but offers the possibility of *scientific explorations* at no other cost than reimbursement of the expense for the materials wasted in the experiments."

Further, with reference to a remark in the memorial to the effect that in respect to the promotion of science, the British Government confines its action almost exclusively to scientific instruction, and fatally neglects the advancement of science, my informant tells me that, in Germany, "professors, preceptors, and teachers of secondary schools are engaged on account of their skilfulness in *teaching*; but professors of universities are never engaged unless they have already proved, *by their own investigations*, that they are to be relied upon for the *advancement of science.* Therefore every shilling spent for instruction in universities is at the same time profitable to the advancement of science."

The physical laboratories which have grown up in the Universities of Glasgow and Edinburgh, and in Owen's College, Manchester, show the want felt of colleges of research; but they go but infinitesimally toward supplying it, being absolutely destitute of means, material or personal, for advancing science except at the expense of volunteers, or securing that volunteers shall be found to continue even such little work as at present is carried on.

The whole of Andrew's splendid work in Queen's College, Belfast, has been done under great difficulties and disadvantages, and at great personal sacrifices; and up to the present time there is not a student's physical laboratory in any one of the Queen's Colleges in Ireland—a want which surely ought not to remain unsupplied. Each of these institutions (the four Scotch universities, the three Queen's Colleges, and Owen's College, Manchester) requires two professors of Natural Philosophy—one who shall be responsible for the teaching, the other for the advancement of science by experiment. The University of Oxford has already established a physical laboratory. The munificence of its Chancellor is about to supply the University of Cambridge with a splendid laboratory, to be constructed under the eye of Prof. Clerk Maxwell. On this subject I shall say no more at present, but simply read a sentence which was spoken by Lord Milton in the first Presidential Address to the British Association, when it met at York in the year 1831:—"In addition to other more direct benefits, these meetings [of the British Association], I hope, will be the means of impressing on the Government the conviction, that the love of scientific pursuits, and the means of pursuing them, are not confined to the metropolis; and I hope that when the Government is fully impressed with the knowledge of the great desire entertained to promote science in every part of the empire, they will see the necessity of affording it due encouragement, and of giving every proper stimulus to its advancement."

Besides abstracts of papers read, and discussions held, before the Sections, the annual Reports of the British Association contain a large mass of valuable matter of another class. It was an early practice of the Association, a practice that might well be further developed, to call occasionally for a special report on some particular branch of science from a man eminently qualified for the task. The reports received in compliance with these invitations have all done good service in their time, and they remain permanently useful as landmarks in the history of science. Some of them have led to vast practical results; others of a more abstract character are valuable to this day as powerful and instructive condensations and expositions of the branches of science to which they relate. I cannot better illustrate the two kinds of efficiency realized in this department of the Association's work than by referring to Cayley's 'Report on Abstract Dynamics,' and Sabine's 'Report on Terrestrial Magnetism,' (1838).

To the great value of the former, personal experience of benefit received enables me, and gratitude impels me, to testify. In a few pages full of precious matter, the generalized dynamical equations of Lagrange, the great principle evolved from Maupertius' "least action" by Hamilton, and the later developments and applications of the Hamiltonian principle by other authors, are described by Cayley so suggestively that the reading of thousands of quarto pages of papers scattered through the *transactions* of the various learned societies of Europe is rendered superfluous for any one who desires only the essence of these investigations, with no more of detail than is necessary for a thorough and practical understanding of the subject.

Terrestrial Magnetism.

Sabine's Report of 1838 concludes with the following sentence:—"Viewed in itself and its various relations, the magnetism of the earth cannot be counted less than one of the most important branches of the physical history of the planet we inhabit; and we may feel quite assured that the completion of our knowledge of its distribution on the surface of the earth would be regarded by our contemporaries and by posterity as a fitting enterprise of a maritime people, and a worthy achievement of a nation which has ever sought to rank foremost in every arduous and honorable undertaking." An immediate result of this report was that the enterprise which it proposed was recommended to the Government by a joint Committee of the British Association and the Royal Society with such success, that Capt. James Ross was sent in command of the Erebus and Terror to make a magnetic survey of the Antarctic regions, and to plant on his way three magnetical and meteorological observatories, at St. Helena, the Cape, and Van Diemen's Land. A vast mass of precious observations, made chiefly on board ship, were brought home from this expedition. To deduce the desired results from them, it was necessary to eliminate the disturbance produced by the ship's magnetism; and Sabine asked his friend Archibald Smith to work out from Poisson's mathematical theory, then the only available guide, the formulæ required for the purpose. This voluntary task Smith executed skillfully and successfully. It was the beginning of a series of labors carried on with most remarkable practical tact, with thorough analytical skill, and with a rare extreme of disinterestedness, in the intervals of an arduous profession, for the purpose of perfecting and simplifying the correction of the mariner's compass —a problem which had become one of vital importance for navigation, on account of the introduction of iron ships. Edition after edition of the 'Admiralty Compass Manual' has been produced by the able Superintendent of the Compass Department, Capt. Evans, containing chapters of mathematical investigation and formulæ by Smith, on which depend wholly the practical analysis of compass observations and rules for the safe use of the compass in navigation. I firmly believe that it is to the thoroughly scientific method thus adopted by the Admiralty that no iron ship of her Majesty's Navy has ever been lost through errors of the compass. The 'British Admiralty Compass Manual' is adopted as a guide by all the navies of the world. It has been translated into Russian, German, and Portuguese; and it is at present being translated into French. The British Association may be gratified to know that the possibility of navigating ironclad war-ships with safety depends on the application of scientific principles given to the world by three mathematicians, Poisson, Airy, and Archibald Smith.

Returning to the science of terrestrial magnetism, we find in the reports of early years of the British Association ample evidence of its diligent cultivation. Many of the chief scientific men of the day from England, Scotland, and Ireland found a strong attraction to the Association in the facilities which it afforded to them for coöperating in their work on this subject. Lloyd, Phillips, Fox, Ross, and Sabine made magnetic observations all over Great Britain; and their results, collected by Sabine, gave for the first time an accurate and complete survey of terrestrial magnetism over the area of this island. I am informed, by Prof. Phillips, that, in the beginning of the Association, Herschel, though a "sincere well-wisher," felt doubt as to the general utility and probable success of the plan and purpose proposed; but his zeal for terrestrial magnetism brought him from being merely a sincere well-wisher to join actively and cordially in the work of the Association. "In 1838 he began to give effectual aid in the great question of magnetical observatories, and was indeed foremost among the supporters of that which is really Sabine's great work. At intervals, until about 1858, Herschel continued to give effectual aid." Sabine has carried on his great work without intermission to the present day; thirty years ago he gave to Gauss a large part of the data required for working out the spherical harmonic analysis of terrestrial magnetism over the whole earth. A recalculation of the harmonic analysis for the altered state of terrestrial magnetism of the present time has been undertaken by Adams. He writes to me that he has "already begun some of the introductory work, so as to be ready, when Sir Edward Sabine's tables of the values of the magnetic elements deduced from observation are completed, at once to make use of them," and that he intends to take into account terms of at least one order beyond those included by Gauss. The form in which the requisite data are to be presented to him is a magnetic chart of the whole surface of the globe. Materials from scientific travelers of all nations, from our home magnetic observatories, from the magnetic observatories of St. Helena, the Cape, Van Diemen's Land, and Toronto, and from the scientific observatories of other countries, have been brought together by Sabine. Silently, day after day, night after night, for a quarter of a century, he has toiled with one constant assistant always by his side, to reduce these observations and prepare for the great work. At this moment, while we are here assembled, I believe that, in their quiet summer retirement in Wales, Sir Edward and Lady Sabine are at work on the magnetic chart of the world. If two years of life and health are granted to them, science will be provided with a key which must powerfully conduce to the ultimate opening up of one of the most refractory enigmas of cosmical physics, the cause of terrestrial magnetism.

To give any sketch, however slight, of scientific investigation performed during the past year, would, even if I were competent for the task, far exceed the limits within which I am confined on the present occasion. A detailed account of work done and knowledge gained in science Britain ought to have every year. The *Journal of the Chemical Society* and the *Zoological Record* do excellent service by giving abstracts of all papers published in their departments. The admirable example afforded by the German *Fortschritte* and *Jahresbericht* is before us; but hitherto, so far as I know, no attempt has been made to follow it in Britain. It is true that several of the annual volumes of the *Jahresbericht* were translated; but a translation, published necessarily at a considerable interval of time after the original, cannot supply the want. An independent British publication is for many obvious reasons desirable. The two publications, in German and English, would, both by their differences and by their agreements, illustrate the progress of science more correctly and usefully than any single work could do, even if appearing simultaneously in the two languages. It seems to me that to promote the establishment of a British year-book of science is an object to which the powerful action of the British Association would be thoroughly appropriate.

In referring to recent advances in several branches of science, I simply choose some of these which have struck me as most notable.

Accurate and minute measurement.

Accurate and minute measurement seems to the non-scientific imagination a less lofty and dignified work than looking for something new. But nearly all the grandest discoveries of science have been but the rewards of accurate measurement and patient long-continued labor in the minute sifting of numerical results. The popular idea of Newton's grandest discovery is that the theory of gravitation flashed into his mind, and so the discovery was made. It was by a long train of mathematical calculation, founded on results accumulated through prodigious toil of practical astronomers, that Newton first demonstrated the forces urging the planets towards the Sun, determined the magnitudes of those forces, and discovered that a force following the same law of variation with distance urges the Moon toward the Earth. *Then* first, we may suppose, came to him the idea of the universality of gravitation; but when he attempted to compare the magnitude of the force on the Moon with the magnitude of the force of gravitation of a heavy body of equal mass at the Earth's surface, he did not find the agreement which the law he was discovering required. Not for years after would he publish his discovery as made. It is recounted that, being present at a meeting of the Royal Society, he heard a paper read, describing geodesic measurement by Picard, which led to a serious correction of the previously accepted estimate of the Earth's radius. This was what Newton required. He went home with the result, and commenced his calculations, but felt so much agitated that he handed over the arithmetical work to a friend: then (and not when, sitting in a garden, he saw an apple fall) did he ascertain that gravitation keeps the Moon in her orbit.

Faraday's discovery of specific inductive capacity, which inaugurated the new philosophy tending to discard action at a distance, was the result of minute and accurate measurement of electric forces.

Joule's discovery of thermo-dynamic law through the regions of electro-chemistry, electro-magnetism, and elasticity of gases. was based on a delicacy of thermometry which seemed simply impossible to some of the most distinguished chemists of the day.

Andrew's discovery of the continuity between the gaseous and liquid states was worked out by many years of laborious and minute measurement of phenomena scarcely sensible to the naked eye.

Great service has been done to science by the British Association in promoting accurate measurement in various subjects. The origin of exact science in terrestrial magnetism is traceable to Gauss's invention of methods of finding the magnetic intensity in absolute measure. I have spoken of the great work done by the British Association in carrying out the application of this invention in all parts of the world. Gauss's colleague in the German Magnetic Union, Weber, extended the practice of absolute measurement to electric currents, the resistance of an electric conductor, and the electromotive force of a galvanic element. He showed the relation beween electrostatic and electromagnetic units for absolute measurement, and made the beautiful discovery that resistance, in absolute electromagnetic measure, and the reciprocal of resistance, or, as we call it, "conducting power," in electrostatic measure, are each of them a velocity. He made an elaborate and difficult series of experiments to measure the velocity which is equal to the conducting power in electrostatic measure, and at the same time to the resistance in electromagnetic measure, in one and the same conductor. Maxwell, in making the first advance along a road of which Faraday was the pioneer, discovered that this velocity is physically related to the velocity of light, and that, on a certain hypothesis regarding the elastic medium concerned, it may be exactly equal to the velocity of light. Weber's measurement verifies approximately this equality, and stands in science *monumentum ære perennius*, celebrated as having suggested this most grand theory, and as having afforded the first quantitative test of the recondite properties of matter on which the relations between electricity and light depend. A re-measurement of Weber's critical velocity on a new plan by Maxwell himself, and the important correction of the velocity of light by Foucault's laboratory experiments, verified by astronomical observation, seems to show a still closer agreement. The most accurate possible determination of Weber's critical velocity is just now a primary object of the Association's Committee on Electric Measurement; and it is at present premature to speculate as to the closeness of the agreement between that velocity and the velocity of light. This leads me to remark how much science, even in its most lofty speculations, gains in return for benefits conferred by its application to promote the social and material welfare of man. Those who perilled and lost their money in the original Atlantic telegraph were impelled and supported by a sense of the grandeur of their enterprise, and of the world-wide benefits which must flow from its success; they were, at the same time, not unmoved by the beauty of the scientific problem directly presented to them; but they little thought that it was to be immediately, through their work, that the scientific world was to be instructed in a long-neglected and discredited fundamental electric discovery of Faraday's, or that again, when the assistance of the British Association was invoked to supply their electricians with methods for absolute measurement (which they found necessary to secure the best economical return for their expenditure, and to obviate and detect those faults in their electric material which had led to disaster), they were laying the foundation for accurate electric measurement in every scientific laboratory in the world, and initiating a train of investigation which now sends up branches into the loftiest regions and subtlest ether of natural philosophy. Long may the British Association continue a bond of union, and a medium for the interchange of good offices between science and the world!

Kinetic Theory of Gases—Atoms.

The greatest achievement yet made in molecular theory of the properties of matter is the kinetic theory of gases, shadowed forth by Lucretius, definitely stated by Daniel Bernoulli, largely developed by Herapath, made a reality by Joule, and worked out to its present advanced state by Clausius and Maxwell. Joule, from his dynamical equivalent of heat, and his experiments upon the heat produced by the condensation of gas, was able to estimate the average velocity of the ultimate molecules or atoms composing it. His estimate for hydrogen was 6,225 feet per second at temperature 60° Fahr., and 6,055 feet per second at the freezing point. Clausius took fully into account the impacts of molecules on one another, and the kinetic energy of *relative* motions of the matter constituting an individual atom. He investigated the relation between their diameters, the number in a given space, and the mean length of path from impact to impact, and so gave the foundation for estimates of the absolute dimensions of atoms, to which I shall refer later. He explained the slowness of gaseous diffusion by the mutual impacts of the atoms, and laid a secure foundation for a complete theory of the diffusion of fluids, previously a most refractory enigma. The deeply penetrating genius of Maxwell brought in viscosity and thermal conductivity, and thus completed the dynamical explanation of all the known properties of gases, except their electric resistance and brittleness to electric force.

No such comprehensive molecular theory had ever been even imagined before the nineteenth century. Definite and complete in its area as it is, it is but a well-drawn part of a great chart, in which all physical science will be represented with every property of matter shown in dynamical relation to the whole. The prospect we now have of an early completion of this chart is based on the assumption of atoms. But there can be no permanent satisfaction to the mind in explaining heat, light, elasticity, diffusion, electricity and magnetism in gases, liquids, and solids, and describing precisely the relations of these different states of matter to one another by statistics of great numbers of atoms, when the properties of the atom itself are simply assumed. When the theory, of which we have the first installment in Clausius and Maxwell's work, is complete, we are but brought face to face with a superlatively grand question,—what is the inner mechanism of the atom?

In the answer to this question we must find the explanation not only of the atomic elasticity, by which the atom is a chronometric vibrator, according to Stoke's discovery, but of chemical affinity and of the differences of quality of different chemical elements, at present a mere mystery in science. Helmholtz's exquisite theory of vortex-motion in an incompressible frictionless liquid has been suggested as a finger-post, pointing a way which may possibly lead to a full understanding of the properties of atoms, carrying out the grand conception of Lucretius, who "admits no subtle ethers, no variety of elements with fiery, or watery, or light, or heavy principles; nor supposes light to be one thing, fire another, electricity a fluid, magnetism a vital principle; but treats all phenomena as mere properties or accidents of simple matter." This statement I take from an admirable paper on the atomic theory of Lucretius, which appeared in the *North British Review* for March, 1868, containing a most interesting and instructive summary of ancient and modern doctrine regarding atoms. Allow me to read from that article one other short passage, finely describing the present aspect of atomic theory:—"The existence of the chemical atom, already quite a complex little world, seems very probable; and the description of the Lucretian atom is wonderfully applicable to it. We are not wholly without hope that the real weight of each such atom may some day be known—not merely the relative weight of the several atoms, but the number in a given volume of any material; that the form and motion of the parts of each atom and the distances by which they are separated may be calculated; that the motions by which they produce heat, electricity, and light may be illustrated by exact geometrical diagrams; and that the fundamental properties of the intermediate and possibly constituent medium may be arrived at. Then the motion of planets and music of the spheres will be neglected for a while in admiration of the maze in which the tiny atoms run."

Even before this was written some of the anticipated results had been partially attained. Loschmidt in Vienna had shown, and not much later Stoney independently in England showed, how to deduce from Clausius and Maxwell's kinetic theory of gases a superior limit to the number of atoms in a given measurable space. I was unfortunately quite unaware of what Loschmidt and Stoney had done when I made a similar estimate on the same foundation, and communicated it to *Nature*, in an article 'On the size of atoms.' But questions of personal priority, however interesting they may be to the persons concerned, sink into insignificance in the prospect of any gain of deeper insight into the secrets of nature. The triple coincidence of independent reasoning in this case is valuable as confirmation of a conclusion violently contravening ideas and opinions which had been almost universally held regarding the dimensions of the molecular structure of matter. Chemists and other naturalists had been in the habit of evading questions as to the hardness or indivisibility of atoms by virtually assuming them to be infinitely small and infinitely numerous. We must now no longer look upon the atom, with Boscovich, as a mystic point endowed with inertia and the attribute of attracting or repelling other such centers with forces depending upon the intervening distances (a supposition only tolerated with the tacit assumption that the inertia and attraction of each atom is infinitely small and the number of atoms infinitely great), nor can we agree with those who have attributed to the atom occupation of space with infinite hardness and strength (incredible in any finite body); but we must realize it as a piece of matter of measurable dimensions, with shape, motion, and laws of action, intelligible subjects of scientific investigation.

Spectrum Analysis.

The prismatic analysis of light discovered by Newton was estimated by himself as being "the oddest, if not the most considerable, detection which had hitherto been made in the operations of nature."

Had he not been deflected from the subject, he could not have failed to obtain a pure spectrum; but this, with the inevitably consequent discovery of the dark lines, was reserved for the nineteenth century. Our fundamental knowledge of the dark lines is due solely to Fraunhofer. Wollaston saw them, but did not discover them. Brewster labored long and well to perfect the prismatic analysis of sunlight; and his observations on the dark bands produced by the absorption of interposed gases and vapors laid important foundations for the grand superstructure which he scarcely lived to see. Piazzi Smyth, by spectroscopic observation performed on the Peak of Teneriffe, added greatly to our knowledge of the dark lines produced in the solar spectrum by the absorption of our own atmosphere. The prism became an instrument for chemical qualitative analysis in the hands of Fox, Talbot and Herschel who first showed how through it the old "blowpipe test," or generally the estimation of substances from the colors which they give to flames, can be prosecuted with an accuracy and a discriminating power not to be attained when the color is judged by the unaided eye. But the application of this test to solar and stellar chemistry had never, I believe, been suggested, either directly or indirectly, by any other naturalist, when Stokes taught it to me in Cambridge, at some time prior to the summer of 1852. The observational and experimental foundations on which he built were:—

(1) The discovery by Fraunhofer of a coincidence between his double dark line D of the solar spectrum and a double bright line which he observed in the spectra of ordinary artificial flames.

(2) A very rigorous experimental test of this coincidence by Prof. W. H. Miller, which showed it to be accurate to an astonishing degree of minuteness.

(3) The fact that the yellow light given out when salt is thrown on burning spirit consists almost solely of the two nearly identical qualities which constitute that double bright line

(4) Observations made by Stokes himself, which showed the bright line D to be absent in a candle-flame when the wick was snuffed clean, so as not to project into the luminous envelope, and from an alcohol flame when the spirit was burned in a watch-glass. And,

(5) Foucault's admirable discovery (*L'Institut*, Feb. 7, 1849), that the voltaic arc between charcoal points is "a medium which emits the rays D on its own account, and at the same time absorbs them when they come from another quarter."

The conclusions, theoretical and practical, which Stokes taught me, and which I gave regularly afterwards in my public lectures in the University of Glasgow, were:—

(1) That the double line D, whether bright or dark, is due to vapor of sodium.

(2) That the ultimate atom of sodium is susceptible of regular elastic vibrations, like those of a tuning-fork or of stringed musical instruments; that like an instrument with two strings tuned to approximate unison, or an approximately circular elastic disc, it has two fundamental notes or vibrations of approximately equal pitch; and that the periods of these vibrations are precisely the periods of the two slightly different yellow lights constituting the double bright line D.

(3) That when vapor of sodium is at a high enough temperature to become itself a source of light, each atom executes these two fundamental vibrations simultaneously; and that therefore the light proceeding from it is of the two qualities constituting the double bright line D.

(4) That when vapor of sodium is present in space across which light from another source is propagated, its atoms, according to a well-known general principle of dynamics, are set to vibrate in either or both of those fundamental modes, if some of the incident light is of one or other of their periods, or some of one and some of the other; so that the energy of the waves of those particular qualities of light is converted into thermal vibrations of the medium, and dispersed in all directions, while light of all other qualities, even though very nearly agreeing with them, is transmitted with comparatively no loss.

(5) That Fraunhofer's double dark line D of solar and stellar spectra is due to the presence of vapor of sodium in atmospheres

surrounding the sun and those stars in whose spectra it had been observed.

(6) That other vapors than sodium are to be found in the atmospheres of sun and stars by searching for substances producing in the spectra of artificial flames bright lines coinciding with other dark lines of the solar and stellar spectra than the Fraunhofer line D:

The last of these propositions I felt to be confirmed (it was, perhaps, partly suggested) by a striking and beautiful experiment, admirably adapted for lecture illustrations, due to Foucault, which had been shown to me by M. Duboscque Soleil and the Abbé Moigno, in Paris, in the month of October, 1850. A prism and lenses were arranged to throw upon a screen an approximately pure spectrum of a vertical electric arc between charcoal poles of a powerful battery, the lower one of which was hollowed like a cup. When pieces of copper and pieces of zinc were separately thrown into the cup, the spectrum exhibited, in perfectly definite positions, magnificent well-marked bands of different colors characteristic of the two metals. When a piece of brass, compounded of copper and zinc, was put into the cup, the spectrum showed all the bands, each precisely in the place in which it had been seen when one metal or the other had been used separately.

It is much to be regretted that this great generalization was not published to the world twenty years ago. I say this, not because it is to be regretted that Angström should have the credit of having, in 1853, published independently the statement that "an incandescent gas emits luminous rays of the same refrangibility as those which it can absorb"; or that Balfour Stewart should have been unassisted by it when, coming to the subject from a very different point of view, he made, in his extension of the 'Theory of Exchanges' (*Edin. Transactions*, 1858–59) the still wider generalization that the radiating power of every kind of substance is equal to its absorbing power for every kind of ray; or that Kirchhoff also should have, in 1859, independently discovered the same proposition, and shown its application to solar and stellar chemistry; but because we might now be in possession of the inconceivable riches of astronomical results which we expect from the next ten years' investigation by spectrum analysis, had Stokes given his theory to the world when it first occurred to him.

To Kirchhoff belongs, I believe, solely the great credit of having first actually sought for and found other metals than sodium in the sun by the method of spectrum analysis. His publication of October, 1859, inaugurated the practice of solar and stellar chemistry, and gave spectrum analysis an impulse to which in a great measure is due its splendidly successful cultivation by the labors of many able investigators within the last ten years.

To prodigious and wearing toil of Kirchhoff himself, and of Angström, we owe large-scale maps of the solar spectrum, incomparably superior in minuteness and accuracy of delineation to anything ever attempted previously. These maps now constitute the standards of reference for all workers in the field. Plücker and Hittorf opened ground in advancing the physics of spectrum analysis, and made the important discovery of changes in the spectra of ignited gases produced by changes in the physical condition of the gas. The scientific value of the meetings of the British Association is well illustrated by the fact that it was through conversation with Plücker at the Newcastle meeting that Lockyer was first led into the investigation of the effects of varied pressure on the quality of the light emitted by glowing gas which he and Frankland have prosecuted with such admirable success. Scientific wealth tends to accumulation according to the law of compound interest. Every addition to knowledge of properties of matter supplies the naturalist with new instrumental means for discovering and interpreting phenomena of nature, which in their turn afford foundations for fresh generalizations, bringing gains of permanent value into the great storehouse of philosophy. Thus Frankland, led from observing the want of brightness of a candle burning in a tent on the summit of Mont Blanc, to scrutinize Davy's theory of flame, discovered that brightness without incandescent solid particles is given to a purely gaseous flame by augmented pressure, and that a dense ignited gas gives a spectrum comparable with that of the light from an incandescent solid or liquid. Lockyer joined him; and the two found that every incandescent substance gives a continuous spectrum—that an incandescent gas under varied pressure gives bright bars across the continuous spectrum, some of which, from the sharp, hard and fast lines observed where the gas is in a state of extreme attenuation, broaden out on each side into nebulous bands as the density is increased, and are ultimately lost in the continuous spectrum when the condensation is pushed on till the gas becomes a fluid no longer to be called gaseous. More recently they have examined the influence of temperature, and have obtained results which seem to show that a highly attenuated gas, which at a high temperature gives several bright lines, gives a smaller and smaller number of lines, of sufficient brightness to be visible, when the temperature is lowered, the density being kept unchanged. I cannot refrain here from remarking how admirably this beautiful investigation harmonizes with Andrews's great discovery of continuity between the gaseous and liquid states. Such things make the life-blood of science.

In contemplating them we feel as if led out from narrow waters of scholastic dogma to a refreshing excursion on the broad and deep ocean of truth, where we learn from the wonders we see that there are endlessly more and more glorious wonders still unseen.

Stokes's dynamical theory supplies the key to the philosophy of Frankland and Lockyer's discovery. Any atom of gas, when struck and left to itself, vibrates with perfect purity its fundamental note or notes. In a highly attenuated gas each atom is very rarely in collision with other atoms, and therefore is nearly at all times in a state of true vibration. Hence the spectrum of a highly attenuated gas consists of one or more perfectly sharp, bright lines, with a scarcely perceptible continuous gradation of prismatic color. In denser gas each atom is frequently in collision, but still is for much more time free, in intervals between collisions, than engaged in collision; so that not only is the atom itself thrown sensibly out of tune during a sensible proportion of its whole time, but the confused jangle of vibrations in every variety of period during the actual collision becomes more considerable in its influence. Hence bright lines in the spectrum broaden out somewhat, and the continuous spectrum becomes less faint. In still denser gas each atom may be almost as much time in collision as free, and the spectrum then consists of broad nebulous bands crossing a continuous spectrum of considerable brightness. When the medium is so dense that each atom is always in collision, that is to say, never free from influence of its neighbours, the spectrum will generally be continuous, and may present little or no appearance of bands, or even of maxima of brightness. In this condition the fluid can be no longer regarded as a gas, and we must judge of its relation to the vaporous or liquid states according to the critical conditions discovered by Andrews.

Spectroscopic Research in Astronomy.

While these great investigations of properties of matter were going on, naturalists were not idle with the newly-recognized power of the spectroscope at their service. Chemists soon followed the example of Bunsen in discovering new metals in terrestrial matter by the old blow-pipe and prism test of Fox, Talbot and Herschel. Biologists applied spectrum analysis to animal and vegetable chemistry, and to sanitary investigations. But it is in astronomy that spectroscopic research has been carried on with the greatest activity, and been most richly rewarded with results. The chemist and the astronomer have joined their forces. An astronomical observatory has now appended to it a stock of re-agents such as hitherto was only to be found in the chemical laboratory. A devoted corps of volunteers of all nations, whose motto might well be *Ubique*, have directed their artillery to every region of the universe. The Sun, the spots on his surface, the corona and the red and yellow prominences seen round him during total eclipses, the moon, the planets, comets, auroras, nebulæ, white stars, yellow stars, red stars, variable and temporary stars, each, tested by the prism, was compelled to show its distinguishing prismatic colours. Rarely before in the history of science has enthusiastic perseverance directed by penetrative genius produced within ten years so brilliant a succession of discoveries. It is not merely the *chemistry* of sun and stars, as first suggested, that is subjected to analysis by the spectroscope. Their whole laws of being are now subjects of direct investigation; and already we have glimpses of their evolutional history through the stupendous power of this most subtle and delicate test. We had only solar and stellar chemistry; we now have solar and stellar physiology.

It is an old idea that the color of a star may be influenced by its motion relatively to the eye of the spectator, so as to be tinged with red if it moves from the earth, or blue if it moves toward the earth. William Allen Miller, Huggins, and Maxwell showed how, by aid of the spectroscope, this idea may be made the foundation of a method of measuring the relative velocity with which a star approaches to or recedes from the earth. The principle is, first to identify, if possible, one or more of the lines in the spectrum of the star, with a line or lines in the spectrum of sodium, or some other terrestrial substance, and then (by observing the star and the artificial light simultaneously by the same spectroscope) to find the difference, if any, between their refrangibilities. From this difference of refrangibility the ratio of the periods of the two lights is calculated, according to data determined by Fraunhofer from comparisons between the positions of the dark lines in the prismatic spectrum and in his own "interference spectrum" (produced by substituting for the prism a fine grating). A first comparatively rough application of the test by Miller and Huggins to a large number of the principal stars of our skies, including Aldebaran, α Orionis, β Pegasi, Sirius, α Lyræ, Capella, Arcturus, Pollux, Castor (which they had observed rather for the chemical purpose than for this), proved that not one of them had so great a velocity as 315 kilomètres per second to or from the earth, which is a *most momentous result in respect to cosmical dynamics.* Afterward Huggins made special observations of the velocity test, and succeeded in making the measurement in one case, that of Sirius, which he then found to be receding from the Earth at a rate of 66 kilomètres per second. This, corrected for the velocity of the Earth at the time of the observation, gave a velocity of Sirius, relatively to the Sun, amounting to 47 kilomètres per second. The minuteness of the difference to be measured, and the smallness of the amount of light even when the brightest star is observed, render the observation extremely difficult. Still, with such great skill as Mr. Huggins has brought to bear on the investigation, it can scarcely be doubted that velocities of many other stars may be measured. What is now wanted is, certainly not greater skill, perhaps not even more powerful instruments, but *more instruments and more observers.* Lockyer's applications of the velocity test to the relative motions of different gases in the Sun's photosphere, spots, chromosphere, and chromospheric prominences, and his observations of the varying spectra presented by the same substance as it moves from one position to another in the Sun's atmosphere, and his interpretations of these observations, according to the laboratory results of Frankland and himself, go far toward confirming the conviction that in a few years all the marvels of the Sun will be dynamically explained according to known properties of matter.

During six or eight precious minutes of time, spectroscopes have been applied to the solar atmosphere and to the corona seen round the dark disc of the Moon eclipsing the Sun. Some of the wonderful results of such observations, made in India on the occasion of the eclipse of August, 1868, were described by Prof. Stokes in a previous address. Valuable results have, through the liberal assistance given by the British and American Governments, been obtained also from the total eclipse of last December, notwithstanding a generally unfavorable condition of weather. It seems to have been proved that at least some sensible part of the light of the "corona" is a terrestrial atmospheric halo or dispersive reflexion of the light of the glowing hydrogen and "helium" round the Sun. (Frankland and Lockyer find the yellow prominences to give a very decided bright line not far from D, but hitherto not identified with any terrestrial flame. It seems to indicate a new substance, which they propose to call Helium.) I believe I may say, on the present occasion, when preparation must again be made to utilize a total eclipse of the Sun, that the British Association confidently trusts to our Government exercising the same wise liberality as heretofore in the interests of science.

Solar Heat.

The old nebular hypothesis supposes the solar system and other similar systems through the universe which we see at a distance as stars, to have originated in the condensation of fiery nebulous matter. This hypothesis was invented before the discovery of the thermo-dynamics, or the nebulæ would not have been supposed to be fiery; and the idea seems never to have occurred to any of its inventors or early supporters that the matter, the condensation of which they supposed to constitute the Sun and stars, could have been other than fiery in the beginning. Mayer first suggested that the heat of the Sun may be due to gravitation; but he supposed meteors falling in to keep always generating the heat which is radiated year by year from the Sun. Helmholtz, on the other hand, adopting the nebular hypothesis, showed in 1854 that it was not necessary to suppose the nebulous matter to have been originally fiery, but that mutual gravitation between its parts may have generated the heat to which the present high temperature of the Sun is due. Further, he made the important observations that the potential energy of gravitation in the Sun is even now far from exhausted; but that with further and further shrinking more and more heat is to be generated, and that thus we can conceive the Sun even now to possess a sufficient store of energy to produce heat and light, almost as at present, for several million years of time future. It ought, however, to be added that this condensation can only follow from cooling, and therefore that Helmholtz's gravitational explanation of future Sun-heat amounts really to showing that the Sun's thermal capacity is enormously greater, in virtue of the mutual gravitation between the parts of so enormous a mass, than the sum of the thermal capacities of separate and smaller bodies of the same material and same total mass. Reasons for adopting this theory, and the consequences which follow from it, are discussed in an article 'On the Age of the Sun's Heat,' published in *Macmillan's Magazine* for March, 1862.

For a few years Mayer's theory of solar heat had seemed to me probable; but I had been led to regard it as no longer tenable, because I had been in the first place driven, by consideration of the very approximate constancy of the Earth's period of revolution round the Sun for the last 2,000 years, to conclude that "the principal source, perhaps the sole appreciably effective source of the Sun-heat, is in bodies circulating round the Sun at present inside of the Earth's orbit;" and because Le Verrier's researches on the motion of the planet Mercury, though giving evidence of a sensible influence attributable to matter circulating as a great number of small planets within his orbit round the Sun, showed that the amount of matter that could possibly be assumed to circulate at any considerable distance from the Sun must be very small; and therefore, "if the meteoric influx taking place at present is enough to produce any appreciable portion of the heat radiated away, it must be supposed to be from matter circulating round the Sun, within very short distances of his surface. The density of this meteoric cloud would have to be supposed so great that comets could scarcely have escaped as comets actually have escaped, showing no discoverable effects of resistance, after passing his surface within a distance equal to one-eighth of his radius. All things considered, there seems little probability in the hypothesis that solar radiation is compensated to any appreciable degree, by heat generated by meteors falling in, at present; and, as it can be shown that no chemical theory is tenable, it must be concluded as most probable that the Sun is at present merely an incandescent liquid mass cooling."

Thus on purely astronomical grounds was I long ago led to abandon as very improbable the hypothesis that the Sun's heat is supplied dynamically from year to year by the influx of meteors. But now spectrum analysis gives proof finally conclusive against it.

Each meteor circulating round the Sun must fall in along a very gradual spiral path, and before reaching the Sun must have been for a long time exposed to an enormous heating effect from his radiation when very near, and must thus have been driven into vapor before actually falling into the Sun. Thus, if Mayer's hypothesis is correct, friction between vortices of meteoric vapors and the Sun's atmosphere must be the immediate cause of solar heat; and the velocity with which these vapors circulate round equatorial parts of the Sun must amount to 435 kilomètres per second. The spectrum test of velocity applied by Lockyer showed but a twentieth part of this amount as the greatest observed relative velocity between different vapors in the Sun's atmosphere.

At the first Liverpool Meeting of the British Association (1854), in advancing a gravitational theory to account for all the heat, light, and motions of the universe, I urged that the immediately antecedent condition of the matter of which the Sun and planets were formed, not being fiery, could not have been gaseous; but that it probably was solid, and may have been like the meteoric stones which we still so frequently meet with through space. The discovery of Huggins, that the light of the nebulæ, so far as hitherto sensible to us, proceeds from incandescent hydrogen and nitrogen gases, and that the heads of comets also give us light of incandescent gas, seems at first sight literally to fulfill that part of the nebular hypothesis to which I had objected. But a solution, which seems to me in the highest degree probable, has been suggested by Tait. He supposes that it may be by ignited gaseous exhalations proceeding from the collision of meteoric stones that nebulæ and the heads of comets show themselves to us; and he suggested, at a former meeting of the Association, that experiments should be made for the purpose of applying spectrum analysis to the light which has been observed in gunnery trials, such as those at Shoeburyness, when iron strikes against iron at a great velocity, but varied by substituting for the iron various solid materials, metallic or stony. Hitherto this suggestion has not been acted upon; but surely it is one the carrying out of which ought to be promoted by the British Association.

Nature of Comets.

Most important steps have been recently made toward the discovery of the nature of comets; establishing with nothing short of certainty the truth of a hypothesis which had long appeared to me probable,—that they consist of groups of meteoric stones; accounting satisfactorily for the light of the nucleus, and giving a simple and rational explanation of phenomena presented by the tails of comets which had been regarded by the greatest astronomers as almost preternaturally marvelous. The meteoric hypothesis to which I have referred remained a mere hypothesis (I do not know that it was ever even published), until, in 1866, Schiaparelli calculated from observations on the August meteors, an orbit for these bodies which he found to agree almost perfectly with the orbit of the great comet of 1862, as calculated by Oppolzer; and so discovered and demonstrated that a comet consists of a group of meteoric stones. Prof. Newton, of Yale College, United States, by examining ancient records, ascertained that in periods of about thirty-three years, since the year 902, there have been exceptionally brilliant displays of the November meteors. It had long been believed that these interesting visitants came from a train of small detached planets circulating round the Sun, all in nearly the same orbit, and constituting a belt analogous to Saturn's ring; and that the reason for the comparatively large number of meteors which we observe annually about the 14th of November is, that at that time the Earth's orbit cuts through the supposed meteoric belt. Prof. Newton concluded from his investigation that there is a denser part of the group of meteors which extends over a portion of the orbit so great as to occupy about one-tenth or one-fifteenth of the periodic time in passing any particular point, and gave a choice of five different periods for the revolution of this meteoric stream round the Sun, any one of which would satisfy his statistical result. He further concluded that the line of nodes, that is to say, the line in which the plane of the meteoric belt cuts the plane of the Earth's orbit, has a progressive sidereal motion of about $52''\cdot4$ per annum. Here, then, was a splendid problem for the physical astronomer; and, happily, one well qualified for the task took it up. Adams, by the application of a beautiful method invented by Gauss, found that of the five periods allowed by Newton just one permitted the motion of the line of nodes to be explained by the disturbing influence of Jupiter, Saturn, and other planets. The period chosen on these grounds is 33¼ years. The investigation showed further that the form of the orbit is a long ellipse, giving for the shortest distance from the Sun 145 million kilomèters, and for longest distance 2,895 million kilomèters. Adams also worked out the longitude of the perihelion and the inclination of the orbit's plane to the plane of the ecliptic. The orbit which he thus found agreed so closely with that of Temple's Comet I, 1866, that he was able to identify the comet and the meteoric belt.* The same conclusion had been pointed out a few weeks earlier by Schiaparelli, from calculations by himself, on the data supplied by direct observations on the meteors, and independently by Peters, from calculations by Leverrier on the same foundation. It is, therefore, thoroughly established that Temple's Comet I, 1866, consists of an elliptic train of minute planets, of which a few thousands or millions fall to the earth annually about the 14th of November, when we cross their track. We have probably not yet passed through the very nucleus or densest part; but thirteen times, in Octobers and Novembers, from October 13, A. D. 902, to November 14, 1866, inclusive (this last time having been correctly predicted by Prof. Newton), we have passed through a part of the belt greatly denser than the average. The densest part of the train, when near enough to us, is visible as the head of the comet. This astounding result, taken along with Huggins's spectroscopic observations on the light of the heads and tails of comets, confirms most strikingly Tait's theory of comets, to which I have already referred; according to which the comet, a group of meteoric stones, is self-luminous in its nucleus, on account of collisions among its constitutents, while its "tail" is merely a portion of the less dense part of the train illuminated by sunlight, and visible or invisible to us according to circumstances, not only of density, degree of illumination, and nearness, but also of tactic arrangement, as of a flock of birds or the edge of a cloud of tobacco smoke! What prodigious difficulties are to be explained, you may judge from two or three sentences which I shall read from Herschel's Astronomy, and from the fact that even Schiaparelli seems still to believe in the repulsion. "There is, beyond question, some profound secret and mystery of nature concerned in the phenomenon of their tails. Perhaps it is not too much to hope that future observation, borrowing every aid from rational speculation, grounded on the progress of physical science generally (especially those branches of it which relate to the ethereal or imponderable elements), may enable us ere long to penetrate this mystery, and to declare whether it is really *matter* in the ordinary acceptation of the term which is projected from their heads with such extraordinary velocity, and if not *impelled*, at least *directed* in its course, by reference to the Sun, as its point of avoidance." "In no respect is the question as to the materiality of the tail more forcibly pressed on us for consideration than in that of the enormous sweep which it makes round the Sun in *perihelio* in a manner of a straight and rigid rod, *in defiance of the law of gravitation*, nay, even *of the received* laws of motion." "The projection of this ray . . . . to so enormous a length, in a single day, conveys an impression of the intensity of the forces acting to produce such a velocity of material transfer through space, such as no other natural phenomenon is capable of exciting. It is clear that *if we have to deal here with matter, such as we conceive it*, viz., *possessing inertia—at all*, it must be under the dominion of forces incomparably more energetic than gravitation, and quite of a different nature."

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* Signor Schiaparelli, Director of the Observatory of Milan, who, in a letter dated 31st of December, 1866, pointed out that the elements of the orbit of the *August* meteors, calculated from the observed position of their radiant point on the supposition of the orbit being a very elongated ellipse, agreed very closely with those of the orbit of Comet II, 1862, calculated by Dr. Oppolzer. In the same letter Schiaparelli gives elements of the orbit of the November meteors, but these were not sufficiently accurate to enable him to identify the orbit with that of any known comet. On the 21st of January, 1867, M. Leverrier gave more accurate elements of the orbit of the November meteors, and in the *Astronomische Nachrichten* of January 9, Mr. C. F. W. Peters, of Altona, pointed out that these elements closely agreed with those of Temple's Comets (I, 1866), calculated by Dr. Oppolzer, and on February 2, Schiaparelli, having re-calculated the elements of the orbit of the meteors, himself noticed the same agreement. Adams arrived quite independently at the conclusion that the orbit of 33¼ years period is the one which *must* be chosen, out of the five indicated by Prof. Newton. His calculations were sufficiently advanced before the letters referred to appeared, to show that the other four orbits offered by Newton were inadmissible. But the calculations to be gone through to find the secular motion of the node in such an elongated orbit as that of the meteors, were necessarily very long, so that they were not completed till about March, 1867. They were communicated in that month to the Cambridge Philosophical Society, and in the month following to the Astronomical Society.

Think now of the admirable simplicity with which Tait's beautiful "sea-bird analogy," as it has been called, can explain all these phenomena.

Origin of Life.

The essence of science, as is well illustrated by astronomy and cosmical physics, consists in inferring antecedent conditions, and anticipating future evolutions, from phenomena which have actually come under observation. In biology the difficulties of successfully acting up to this ideal are prodigious. The earnest naturalists of the present day are, however, not appalled or paralyzed by them, and are struggling boldly and laboriously to pass out of the mere "Natural History stage" of their study, and bring zoology within the range of Natural Philosophy. A very ancient speculation, still clung to by many naturalists (so much so that I have a choice of modern terms to quote in expressing it) supposes that, under meteorological conditions very different from the present, dead matter may have run together, or crystallized or fermented into "germs of life," or "organic cells," or "protoplasm." But science brings a vast mass of inductive evidence against this hypothesis of spontaneous generation, as you have heard from my predecessor in the Presidential chair. Careful enough scrutiny has, in every case up to the present day, discovered life as antecedent to life. Dead matter cannot become living without coming under the influence of matter previously alive. This seems to me as sure a teaching of science as the law of gravitation. I utterly repudiate, as opposed to all philosophical uniformitarianism, the assumption of "different meteorolgical conditions"—that is to say, somewhat different vicissitudes of temperature, pressure, moisture, gaseous atmosphere—to produce or to permit that to take place by force or motion of dead matter alone, which is a direct contravention of what seems to us biological law. I am prepared for the answer, "our code of biological laws is an expression of our ignorance as well as of our knowledge." And I say, yes; search for spontaneous generation out of inorganic materials; let any one not satisfied with the purely negative testimony of which we have now so much against it, throw himself into the inquiry. Such investigations as those of Pasteur, Pouchet, and Bastian are among the most interesting and momentous in the whole range of Natural History, and their results, whether positive or negative, must richly reward the most careful and laborious experimenting. I confess to being deeply impressed by the evidence put before us by Prof. Huxley, and I am ready to adopt, as an article of scientific faith, true through all space and through all time, that life proceeds from life, and from nothing but life.

How, then, did life originate on the earth? Tracing the physical history of the earth backward, on strict dynamical principles, we are brought to a red-hot melted globe, on which no life could exist. Hence, when the earth was first fit for life, there was no living thing on it. There were rocks solid and disintegrated, water, air all round, warmed and illuminated by a brilliant sun, ready to become a garden. Did grass and trees and flowers spring into existence, in all the fullness of ripe beauty, by a fiat of Creative Power? or did vegetation, growing up from seed sown, spread and multiply over the whole earth? Science is bound, by the everlasting law of honor, to face fearlessly every problem which can fairly be presented to it. If a probable solution, consistent with the ordinary course of nature, can be found, we must not invoke an abnormal act of Creative Power. When a lava stream flows down the sides of Vesuvius or Etna it quickly cools and becomes solid; and after a few weeks or years it teems with vegetable and animal life, which for it originated by the transport of seeds and ova and by the migration of individual living creatures. When a volcanic island springs up from the sea, and after a few years is found clothed with vegetation, we do not hesitate to assume that seeds has been wafted to it through the air, or floated to it on rafts. Is it not possible, and if possible, is it not probable, that the beginning of vegetable life on the earth is to be similarly explained? Every year thousands, probably millions, of fragments of solid matter fall upon the earth—whence come these fragments? What is the previous history of any one of them? Was it created in the beginning of time an amorphous mass? This idea is so unacceptable that, tacitly or explicitly, all men discard it. It is often assumed that all, and it is certain that some, meteoric stones are fragments which had been broken off from greater masses and launched free into space. It is as sure that collisions must occur between great masses moving through space as it is that ships, steered without intelligence directed to prevent collision, could not cross and re-cross the Atlantic for thousands of years with immunity from collisions. When two great masses come into collision in space, it is certain that a large part of each is melted; but it seems also quite certain that in many cases a large quantity of *débris* must be shot forth in all directions, much of which may have experienced no greater violence than individual pieces of rock experience in a land-slip or in blasting by gunpowder. Should the time when this earth comes into collision with another body, comparable in dimensions to itself, be when it is still clothed as at present with vegetation, many great and small fragments carrying seed and living plants and animals would undoubtedly be scattered through space. Hence and because we all confidently believe that there are at present, and have been from time immemorial, many worlds of life besides our own, we must regard it as probable in the highest degree that there are countless seed-bearing meteoric stones moving about through space. If at the present instant no life existed upon this earth, one such stone falling upon it might, by what we blindly call *natural* causes, lead to its becoming covered with vegetation. I am fully conscious of the many scientific objections which may be urged against this hypothesis, but I believe them to be all answerable. I have already taxed your patience too severely to allow me to think of discussing any of them on the present occasion. The hypothesis that life originated on this earth through moss-grown fragments from the ruins of another world may seem wild and visionary; all I maintain is that it is not unscientific.

From the earth stocked with such vegetation as it could receive meteorically, to the earth teeming with all the endless variety of plants and animals which now inhabit it, the step is prodigious; yet, according to the doctrine of continuity, most ably laid before the Association by a predecessor in this chair (Mr. Grove), all creatures now living on earth have proceeded by orderly evolution from some such origin. Darwin concludes his great work on 'The Origin of Species' with the following words:—"It is interesting to contemplate an entangled bank clothed with many plants of many kinds, with birds singing on the bushes, with various insects flitting about, and with worms crawling through the damp earth, and to reflect that these elaborately constructed forms, so different from each other, and dependent on each other in so complex a manner, have all been produced by laws acting around us." . . . . "There is grandeur in this view of life with its several powers, having been originally breathed by the Creator into a few forms or into one; and that, whilst this planet has gone cycling on according to the fixed law of gravity, from so simple a beginning, endless forms, most beautiful and most wonderful, have been and are being evolved." With the feeling expressed in these two sentences I most cordially sympathize. I have omitted two sentences which come between them, describing briefly the hypothesis of "the origin of species by natural selection," because I have always felt that this hypothesis does not contain the true theory of evolution, if evolution there has been in biology. Sir John Herschel, in expressing a favorable judgment on the hypothesis of zoological evolution, with, however, some reservation in respect to the origin of man, objected to the doctrine of natural selection, that it was too like the Laputan method of making books, and that it did not sufficiently take into account a continually guiding and controlling intelligence. This seems to me a most valuable and instructive criticism. I feel profoundly convinced that the argument of design has been greatly too much lost sight of in recent zoological speculations. Reaction against the frivolities of teleology, such as are to be found, not rarely, in the notes of the learned commentators on Paley's 'Natural Theology,' has, I believe, had a temporary effect in turning attention from the solid and irrefragable argument so well put forward in that excellent old book. But overpoweringly strong proofs of intelligent and benevolent design lie all round us, and if ever perplexities, whether metaphysical or scientific, turn us away from them for a time, they come back upon us with irresistible force, showing to us through nature and the influence of a free will, and teaching us that all living beings depend on one ever acting Creator and Ruler.

Art. XXXVII.—*On some new Silurian Crinoids and Shells;* by F. B. Meek.

Dendrocrinus Casei *Meek.*

Compare *Pentacrinite* Christy, 1848; Letters on Geology, Plate II.

Column very distinctly pentagonal, the angles at the connection with the body being continuous with strong ridges passing up the sutures between the basal pieces and to the middle of the subradials. Body pentagonal-obconic, a little wider above than high. Base wider than high, strongly pentagonal, being deeply excavated up the middle of each piece, and very prominent at the lateral sutures; basal pieces wider below than high, pentagonal in form, with the mesial angle above salient, and the superior lateral sloping sides much longer than the lateral. Subradial pieces of moderate size, those seen, hexagonal in form, and all very convex in the middle, from which point they send one strongly elevated ridge to meet others on each of the surrounding plates, and others coming up the sutures between the basals, while on each side of all of these ridges, excepting sometimes those passing to the first radials above, there is usually a smaller, less elevated ridge; the surface of the body being thus divided by these ridges into very profoundly excavated triangular spaces, in the middle of which the corners of the body plates meet. First radial pieces, excepting one on the anal side, larger than the subradials, about as wide as high, with a general pentagonal outline, the upper side being longest and deeply excavated for the reception of the comparatively narrow free radials or arm pieces; one on the right of the anal series, shorter than the others, pentagonal in form, and supporting above another larger radial that is included as a part of the wall of the body, and corresponds with the first radials in the other rays, excepting that it is shorter; all convex and sending a strong ridge to each of the contiguous body plates below, while a number of much smaller ridges pass horizontally across from one to another of these pieces on each side. Arms or free rays, comparatively rather narrow, distinctly rounded on the outer or dorsal side, and composed of transversely oblong pieces that are about twice as wide as long below the first bifurcation; in the first ray on the right of the anal series, bifurcating on the fourth free piece, beyond which they are seen to be long and composed of proportionally narrow pieces; but their mode of bifurcation, if they divide again, and their structure in the other rays, cannot be made out from the specimens at hand. Anal series unknown.

Ventral extension of the body more than four times as long as the latter, and as seen flattened by pressure, of greater breadth; as usual, composed of numerous small equal hexagonal, alternately interlocking pieces, that are strengthened by little oblique costæ so arranged as to present an ascending zigzag appearance. Surface, excepting the strong costæ of the body plates, and the smaller ones of the ventral part, without ornamentation.

Height of body to top of first radials, 0·39 inch, greatest breadt at top, 0·32 inch. Length of incomplete ventral extension, 1·9 inches; breadth of same as flattened, near upper end, 0·65 inch breadth of arms below the first bifurcation, 0·12 inch.

This beautiful species seems to be a true *Dendrocrinus*, as it ca be seen to have two of the primary radials on the right of the ana series, included as a part of the walls of the body, while all it other parts seem to conform to the structure of that group. Th differences between *Dendrocrinus* and *Poteriocrinites* are not ver great, and it is thought by some that the former should stand onl as a subgenus under *Poteriocrinites*. If so, the name of this sp cies when written in full, would be *Poteriocrinites* (*Dendocrinu* *Casei*. In general appearance it resembles *Palæocrinus angulatu* of Billings, but it differs in having the costæ of its body, in par with a smaller one ou each side; while its column is very muc more strongly pentagonal. Of course it also differs in the generi character of having its ventral part extended upward nearly o quite as long as the arms. *

It may be that the species here described is the same figured b Mr. Christy, in his "Letters on Geology," as a Pentacrinite (wit out a specific name), as it came from the same horizon, and fro about the same region of country. It does not, however, agre *exactly* with his figure in details.

The specific name is given in honor of L. B. Case, Esq., of Ric mond, Indiana, to whom I am indebted for the use of the fines specimen of it I have seen. I am also under obligations to C. Dyer, Esq., of Cincinnati, for the use of two smaller, and nearly good specimens. Figures of the species, with a full descriptio will be given in the Ohio Geological Report.

Locality and position.—Mr. Case's specimen was found by hi at Richmond, Indiana, in the upper part of the Cincinnati grou and those belonging to Mr. Dyer were found at about the sam horizon between Cincinnati and Oxford, Ohio.

LEPOCRINITES MOOREI *Meek*.

Body obovate. Base forming nearly one-fourth the height the body, its four pieces being about as wide as long, of near equal size, and irregularly pentagonal in form, excepting one on th anal side, which is hexagonal. The five pieces of the second rang of irregular form and size, two on the anal side being longer tha wide, and extending up to form the lower margin of the princip opening, which is moderately large, and placed about one-third th length of the body below the top. Arrangement of the plat above not clearly made out. Pectinated rhombs four, compar tively large, one situated at the suture between one of the bas pieces and the contiguous piece of the next range above, on th anterior side of the body; another on the side to the left of th opening, and arranged with its longer axis directed transversely, on a line with the opening, while the other two are nearly on a line with the right side of the opening, on three plates that corner together, the arrangement being such that their longer axes diverge at right angles upward; in these, 15 to 20 of the little bars may be counted.

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* Now, since we know the nature of the vault of *Cyathocrinites* (see Proce Phila. Acad., N. Sci., Dec., 1868, p. 324 and 336), it seems to me that *Palæocri* cannot stand as a distinct genius from that group.

Recumbent arms short, or confined mainly to the upper side, one extending down nearly to the opening on the anal side, another to the two rhombs to the right of the opening, a third to that on the left, and the fourth to the anterior side, the direction of all being thus nearly or quite at right angles to each other. Column thick at the base of the body, but tapering rapidly below; as usual, composed of very thin pieces. Surface of body plates marked by distinct radiating lines.

Height of body, 0·46 inch; breadth, about 0·36 inch; thickness of column at its connection with the base, 0·14 inch.

This species seems to agree well with the genus *Lepocrinites* of Conrad, excepting in the very unusual character of having four rhombs, instead of only three. As one of these, however, seems to be merely rudimentary, or in other words, not perforated by little slits, I can scarcely think its presence a generic character.

I believe this is the first example of this group of *Cystidians* that has been found in the Lower Silurian, in this country. It occurs, however, in the upper part of the lower series, where some of the other fossils begin to resemble Upper Silurian types.

It has been proposed to correct the orthography of Mr. Conrad's genus to *Lepadocrinus*, and if this orthography should be adopted, the name of our species would be written *Lepadocrinus* or *Lepadocrinites Moorei*. The most usual custom, however, has been to retain the original orthography of generic names in such cases.

The specific name is given in honor of Prof. Joseph Moore, of ——— College, Richmond, Indiana, to whom I am indebted for the use of the only specimen I have seen.

Locality and position.—Upper part of the Cincinnati group, at Richmond, Indiana.

ANODONTOPSIS ? MILLERI *Meek.*

Shell ovate, rather compressed or only moderately convex, the greatest convexity being a little above and slightly in advance of the middle, extremities more or less narrowly rounded, basal margin longitudinally semi-oval in outline, the most prominent part being near the middle; cardinal margin sloping from the beaks at an angle of 130 ° to 135 ° and rounding into the lateral margins; beaks only moderately prominent, somewhat obtuse, and not very convex, placed more than one-third the length of the valves from the anterior end. Surface smooth, or only with obscure lines of growth.

Length of a medium sized adult specimen, 0·83 inch; height, 0·59 inch; convexity, 0·30 to 33 inch.

It is not without considerable doubt that I refer this shell to McCoy's genus *Anodontopsis*, since it does not seem to correspond exactly in its hinge characters to his description of that genus, if I correctly understand him. As the hinge of *Anodontopsis*, however, has not yet been illustrated, and different authors do not always describe the same hinge exactly in the same way, I have concluded to refer our shell, for the present, provisionally to *Anodontopsis*. If a new genus, however, it may be called *Orthodontiscus*.

Prof. McCoy described the hinge of his genus as follows: "hinge line shorter than the shell, with a posterior long slender tooth or cartilage plate extending just below it (double in the right valve), and another similar but shorter one in front of the beaks," and then adds that there is "occasionally one small cardinal tooth beneath the beak."

In the shell here described, the hinge may be characterized as having one rather well defined, subtrigonal, or somewhat obliquely extended cardinal tooth under the beak of the right valve, and a corresponding pit under the beak of the left valve, with sometimes a slight prominence or rudimentary cardinal tooth just in advance of this pit; while of posterior lateral teeth there is in the right valve one long tooth ranging parallel to the cardinal margin, with a parallel furrow above and below it for the reception of two posterior laters in left valve, the lower one of which is more prominent, and the upper merely linear or rudimentary. The furrow between these two posterior lateral teeth of the left valve is well defined, and receives the tooth between the two furrows in the other valve. Below the lower of these furrows on the posterior side of the right valve, there is a very slight marginal ridge, that may sometimes assume the character of a second posterior lateral, but it is most prominent anteriorly, where it connects with the cardinal tooth, of which it seems rather to be an oblique posterior prolongation, than a distinct tooth. On the anterior side, there is one shorter anterior lateral tooth in the right valve, also ranging parallel to the hinge margin, and above and below this a little furrow for the reception of two small anterior laterals in the left valve, which receive between them that of the right valve.

The pallial line is certainly simple, and the muscular impressions well defined, the posterior one being larger than the other, and provided with a small accessory scar above just under the posterior ends of the posterior lateral teeth. The ligament or cartilage was probably small and internal, as there are no traces of an external ligament to be seen, the valves fitting close all along the hinge margin. No lunule or escutcheon is to be seen in any of the specimens.*

The specific name is given in honor of S. A. Miller, Esq., of Cincinnati, Ohio, who sent on to the Smithsonian Institute the first specimens of this shell I have seen. I am also indebted to him for some broken valves showing the hinge. For the use of a good specimen showing the hinge of the left valve I am likewise under obligations to C. B. Dyer, Esq., of Cincinnati.

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* From all of the known characters of such extinct shells as this, I would be inclined to refer them to the family *Crassatellidæ*, instead of to the *Mytilidæ*, with which Prof. McCoy associates *Anodontopsis*.

Locality and position.—Forty miles west of Cincinnati, Ohio, above the middle of the Cincinnati group, of the Lower Silurian.

ANODONTOPSIS? UNIONOIDES *Meek.*

This species has at least all the external characters of the genus, including the last, but nothing is known of the nature of its hinge. Specifically it differs from the species *Milleri*, not only in being very much larger than the adult size of that shell, but in having its anterior outline more regularly rounded, and its posterior obliquely subtruncated above, and with its most prominent part below the middle. Its ventral margin is also much straighter in outline; while its beaks are more depressed and placed decidedly nearer the anterior side, and its dorsal margin is not declining on the posterior side of the beaks as in the last. It likewise differs in having its posterior umbonal slopes more convex on a line from the beaks to the posterior basal margin.

Length, 1·73 inches; height, 1·11 inches; convexity, 0·63 inch.

Locality and position, same as last. The only specimen I have seen was kindly loaned to me for description and illustration, by Mr. S. A. Miller, of Cincinnati.

Remarks on the genus Lichenocrinus; by F. B. MEEK.

Perhaps of all the remarkable types of that protean order of animals known as the *Crinoidea*, there are few more curious and interesting forms (if really the *body* of a Crinoid) than that for which Prof. Hall proposed the name *Lichenocrinus*. Having recently had an opportunity to examine an extensive series of specimens belonging to both of the known species of this type, in the collections of Mr. C. B. Dyer and other gentlemen of Cincinnati, I propose to make a few remarks on the same, that may be of some interest to paleontologists, especially as this fossil is little known, and the specimens now obtained afford the means of giving a more extended description of its characters than that already published.

Prof. Hall's generic description of this crinoid reads as follows: "Bodies parasitic on shells and other foreign substances. Form discoid or depressed-convex, with a proboscidiform appendage rising from the centre. Disk composed of an indefinite number of polygonal plates, and apparently having no distinct mode of arrangement. Proboscis perforate, and in the known species, formed of five ranges of short plates alternating and interlocking at the margins."

From the specimens now known, the following more extended description of this fossil may be given:

Discoid or depressed-plano-convex bodies, growing firmly attached to shells, corals, trilobites and other marine objects, and entirely destitute of free or recumbent arms or pinnulæ, ambulacral openings or pectinated rhombs. Free or convex side, concave in the central region, and composed of numerous small, non-imbricating polygonal plates, without any definite arrangement; mesial depression provided with a very long, slender, perforated, flexible column-like appendage, composed of five longitudinal series of short, alternately interlocking pieces. Attached side, when separated, presenting no sutures or openings, but in some conditions, showing numerous, distinct regularly arranged, radiating striæ, corresponding to radiating lamellæ that occupy the whole internal cavity from top to bottom.

Among the more remarkable features of this fossil, may be mentioned its very curious system of radiating lamellæ occupying the whole internal cavity, and giving it, when the plates of the upper side are removed so as to expose these lamellæ in place and attached to the adhering side, almost exactly the appearance of the little fungioid coral *Micrabacia.* The entire absence, so far as known, of free or recumbent arms or pinnulæ, as well as of the most minute ambulacral or other openings, save the minute perforation into the slender column-like appendage; and the attachment of this appendage to the free side of the firmly adhering disk, are also very anomalous features, if we view this disk as the body of a crinoid.

On examining one of these fossils, one of the first questions that suggests itself is, what can be the nature of this long slender appendage, not more than four to eight or ten hundredths of an inch in diameter, and several inches in length? Is it homologous with the so-called proboscis or ventral tube of other crinoids, or with the column of the same? Prof. Hall evidently entertained the former opinion at the time he wrote the diagnosis quoted above, though I was informed at Cincinnati, that after seeing other specimens than those from which his diagnosis was written, he inclined to the opinion that it is a column. That one or the other of these views is correct, would almost necessarily seem to be the case, and yet there would appear to be rather strong objections to both of these conclusions, if we view the disk as the body of a crinoid. In the first place, if a column, why should the body, instead of being, as usual, attached by it, be always (when not accidentally detached) found growing firmly by the whole opposite side to foreign bodies, and this long appendage in all cases be left dangling free, and if viewed as a column, apparently useless? Again, if a column, connected with the free side of the body of an attached crinoid, how are we to account for the fact that no traces of any other opening than that passing in through this appendage can be seen, even by a careful examination under a magnifier, in any part of the body? In addition to this, it does not connect with the disk by a series of basal pieces, as is usually the case with the connection of the column of a crinoid or cystoid to the body of the same, but on the contrary, the plates of the disk diminish in size inward, and pass by easy gradations into those forming the base of this long appendage.

On the other hand, if we proceed to view this appendage as a proboscis, or ventral tube, connecting with the ventral side of the body, we are met by the objection of its extreme proportional length, slenderness, flexibility, and the fact that it seems to taper off nearly to a point at its free end. In Mr. Dyer's collection there is a piece, apparently of the free end of this organ, about an inch in length, and agreeing exactly in size, form and structure, with that of *L. Dyeri*, that is broken at one end, and tapers to a slightly blunted point at the other end, which is composed of very minute pieces drawn together. In other examples, where three or four inches in length of this appendage can be seen attached to the disk at one end, it tapers off until it becomes exceedingly slender at the free broken end. This character of its termination, especially when viewed in connection with its length, slenderness and other characters, would seem to be a strong objection to the conclusion that it is a ventral tube or proboscis. Still there might have been a minute opening at the extremity, closed by diminutive pieces, as we often see is the case with the opening of much larger crinoids.

While examining the specimens of this type, several solutions of the mystery of its structure suggested themselves, the first one of which was, that possibly the disk, viewed as the body, might really be only a peculiarly constructed root, or base of attachment of a crinoid, the body of which grew at the free end of the long column-like appendage. This suggestion derives some support from the fact that the disk, although usually growing on the flat surfaces of shells, etc., is sometimes found growing upon the side of the columns of other larger crinoids, as well as on other uneven surfaces, and in such cases, it is bent around to conform to the curve of the surface of attachment, just as we see in crinoid roots similarly situated; while its whole interior is so filled with radiating lamellæ, as to leave extremely little, if any, space for the viscera of an animal, and is, as already stated, apparently hermetically sealed, excepting the minute canal leading up into the long appendage. It is true that the roots of crinoids are generally formed of thickened and anchylosed rings or segments of the column, but Mr. Billings has figured the root of one type (*Cleiocrinus grandis*), apparently composed of an accidentally folded expansion of minute polygonal plates; and it is worthy of note, that the column attached to this root is longitudinally divided by five sutures. It is also true, that there is no example, so far as known to the writer, of any such system of radiated lamellæ being connected with the root of a crinoid; but this objection would doubtless apply with even greater force against the conclusion that this disk is the body of one of these animals.

On the other hand, among the strong objections to the suggestion that these disks are roots, may be mentioned their very regular symmetrical form, and the fact that no indications of a body at the free end of the column-like appendage have yet been observed, nor of a detached body with adhering portions of a column agreeing with this; while no free criniod that might have been attached to this column in its early stages of growth, is known in these rocks. In addition to this, the tapering and pointed extremity of this appendage would seem to render it at least improbable that it had ever supported a body at that end.

Two other solutions of the difficulty suggest themselves, one of which is, that possibly the specimens, as we now see them, may not be the mature condition of the animal, but only one of the stages of development of some Crinoid, which, if known in its adult condition, is supposed to be an entirely distinct type. The other is that the disks, as we now see them growing fast to other bodies, may be the adult condition of a Crinoid that in its earlier stages of growth was supported on its little column, as in other types, being otherwise free, and that at a later period of its growth, the column became free at its lower end, and was, for a time, trailed about by the floating body, which finally inverted itself and grew fast to other objects by what was originally its vault. The fact, however, that these disks attain a diameter of at least half an inch, with the elongated appendage four inches or more in length, would, even, if known analogies supported such a view, seem to be a very strong objection to the conclusion that these are immature, or embryonic forms; while to say nothing of other strong objections that naturally present themselves against the last mentioned suggestion, the occurrence of these disks of all sizes, from the largest down to others less than a tenth of an inch in diameter, all alike growing fast to other bodies by the side opposite the column-like appendage, seems to demonstrate that this is their mode of growth from the first.*

In view of all that is now known of this curious fossil, it seems to me, without undertaking to express a positive opinion on the subject, that the weight of evidence (supposing that these disks are really the *body* of the crinoid) favors the conclusion that the long appendage is a ventral tube; but *if the appendage is a column*, then I should incline to the opinion that the disk is a peculiarly organized root, and that the body may be yet unknown, unless as an entirely distinct crinoid.

For the use of specimens of this fossil, I am under obligations to Mr. C. B. Dyer, Mr. U. P. James, Mr. D. H. Shaffer, Dr. H. H. Hill and Dr. R. M. Byrnes, of Cincinnati. Mr. Dyer's collection, however, contains much the most complete and instructive series. Full illustrations, showing all of its known characters, will be prepared for the reports of the Ohio Geological Survey. The two known species, *L. Dyeri* and *L. crateriformis*, occur in the Cincinnati group of the Lower Silurian, near Cincinnati, Ohio.

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* In a few very rare cases, the disk has been found detached, and showing the flat side marked by very regular radiating striæ. It is almost certain, however, from the fact that hundreds of specimens have been found growing firmly to other bodies, that these few separated individuals had become detached by the disintegration of the object upon which they grew, and that the radiating striæ are only the edges of the lamellæ within, exposed by weathering, as we also sometimes see on the upper side of weathered specimens.

ART. XXXVIII.—*Discovery of a new Planet, and the Elements of the 114th Asteroid;* by Dr. C. H. F. PETERS. (From a letter to one of the editors, dated Litchfield Observatory of Hamilton College, Clinton, Oneida Co., N. Y., September 11, 1871).

ON the night of the 8th inst. a new planet was found, which probably will receive the number (116) of the asteroid group. The weather has favored me, and I have obtained the three following observations:—

	Ham. Coll. m. t.	A.R. (116).	Decl. (116).
1871, Sept. 8.	$15^h\ 33^m\ 34^s$	$0^h\ 14^m\ 6{\cdot}5^s$	$-3^\circ\ 44'\ 38''$
9.	11 47 31	0 13 30·3	−3 48 48
10.	12 38 3	0 12 41·7	−3 54 12

These positions may be slightly modified by adopting more correct places of the stars of comparison. The planet is somewhat brighter than 11th magnitude.

Of the 114th asteroid (which has been named *Cassandra*), I have computed the following elements, from observations of July 28, Aug. 8 and 18:—

Epoch: 1871, Jan. 0. Berlin m. t.

$$\begin{aligned} M_0 &= 118^\circ\ \ 5'\ \ 1''{\cdot}84 \\ &\left.\begin{aligned} \pi &= 148\ \ 29\ \ 23{\cdot}1 \\ \Omega &= 163\ \ 53\ \ 32{\cdot}3 \\ i &= 5\ \ 1\ \ 30{\cdot}05 \end{aligned}\right\}\ \text{Mean Equ. 1871, 0.} \\ \varphi &= 8\ \ 51\ \ 32{\cdot}14 \\ \mu &= 817''{\cdot}54 \\ \log a &= 0{\cdot}4249978. \end{aligned}$$

These represent an observation of Sept. 9 to within a few seconds, and therefore must be very nearly accurate. From them we learn, further, that the planet is really not so very small, but only appeared so in its present opposition. For, we find that it is now in the remoter part of its orbit, near its aphelion.

SCIENTIFIC INTELLIGENCE.

I. PHYSICS.

1. *Researches in Electricity:—Inaugural-Dissertation for the attainment of the Degree of Doctor of Philosophy at the Georg-August-University, Göttingen;* by THOS. R. BAKER, of Pennsylvania, U. S. A.—The prominent part of these researches was the comparison of the spark length of a given quantity of electricity with its density, and also the spark length with the quantity itself. The apparatus used was the Lane discharging jar, the sinus electrometer of R. Kohlrausch, and a large multiplicator

employed by Professors Weber and R. Kohlrausch in their determination of the magnetic and mechanical units of electricity. The sinus electrometer is an apparatus by which the density of electricity is determined by the efforts of a charged magnetic needle (a small magnet) against the horizontal intensity of the earth's magnetism. By means of the multiplicator, the quantity of electricity is estimated by measuring the influence of a current many times multiplied upon a small magnet within it.

The jar and electrometer combined were used for the first part of the investigation. The apparatus was charged, and then by means of a micrometer the negative was made to approach the positive ball of the jar until the spark appeared, and at this instant the position of the needle was noted.

The jar combined with the multiplicator served for the second part of the investigation. The balls of the jar were placed at fixed distances apart; and then the electrical machine, also connected with the apparatus, turned until the appearance of the spark.

The examination of the relation was made by seeking the straight line or curve whose equation the expressions for the elements of comparison in question regarded as coördinates most nearly satisfied.

From the results obtained it is concluded that the relations sought in both parts of the investigation most nearly approach that of the coördinates of the hyperbola, though that relation is not presented as *clearly the physical* law in the case.

The relation of the electrical condition of the atmosphere to its moisture, temperature and pressure, and the effect of motion upon the escape of electricity from the needle, were investigated at the same time. In the latter it was shown that the needle when in motion lost its electrical charge considerably sooner than when at rest.

Millersville, Pa., Aug. 14th 1871.

2. *Water unfrozen at a temperature of* − 18° *C.*—Boussingault finds that by preventing the dilatation of water, it may be kept unfrozen down to −18° C. He experimented with a gun barrel of steel, into which a steel ball was dropped before filling it with water. During the cold days of December 26, 27 and 30, last, the temperature fell to −12° and −18°, and yet on shaking the tube the ball was found to move freely, showing that the water was not frozen.—*L'Institut, July* 12.

II. Geology and Natural History.

1. *Glaciers.*—Canon Moseley has a paper entitled, "On the Mechanical impossibility of the descent of glaciers by their weight alone," in the Philosophical Magazine for August.

2. *Time of the Glacial epoch.*—Lieut.-Col. Drayson in discussing before the Geological Society the "probable cause, date and duration of the Glacial epoch," starts from the fact that the pole of the ecliptic would be the center of polar motion as the pole

varied its distance from that center. He indicated the curve which the pole did trace, and this curve was such as to give for the date 13,000 B. C., a climate very cold in winter, and very hot in summer, for each hemisphere; the duration of the glacial epoch he fixed at about 16,000 years. He stated that the calculation resulting from this movement agreed accurately with observation.—*Phil. Mag. Aug.*, 1871.

3. *Das Elbthalgebirge in Sachsen*, von Dr. Hanns Bruno Geinitz. 1st Part. I. The Sea Sponges of the Lower Quader. 42 pp. 4to. with 10 plates. Cassel, 1871. (Theodor Fischer).—This valuable memoir by Dr. Geinitz notices or describes and admirably figures the following sponges: *Spongia Saxonica* Gein., *Cribrospongia subreticulata* Münster in litt., *Cr. isopleura* Reuss, *Cr. heteromorpha* Reuss, *Cr. bifrons* Reuss, *Plocoscyphia pertusa* Gein., *Amorphospongia vola* Michelin, *Sparsispongia varians* de From., *Tremospongia* (d'Orb.) *pulvinaria* Goldf. sp., *Tr. rugosa* Goldf. sp., *Tr. Klieni* Gein., *Cupulospongia* (d'Orb.) *infundibuliformis* Goldf. sp., *C. Roemeri* Gein., *Stellispongia Plauensis* Gein., *St. Reussi* Gein., *St. Goldfussiana* Gein.., *St. Michelini* Gein., *Epitheles* (de From.) *tetragona* Goldf. sp., *E. foraminosa* id., *E. robusta* Gein., *E. furcata* Goldf. sp., *Cherendopora undulata* Mich., *Ch. pateræformis* Mich., *Elamostoma* (de From.), *Normanianum* d'Orb. sp., *El. consobrinum* id. *Siphonia piriformis* Goldf., *S. annulata* Gein., *S. bovista* Gein. The memoir is a very important contribution to this department of paleontology.

4. *Sieboldtia Davidiana.*—M. Blanchard has described under this name a large Salamander from the north of China, which appears to be different from that of Japan.—*L'Institut, July* 12.

5. *Bivalve Crustaceans.*—A paper on recent Ostracoids, bivalve crustaceans, from the Gulf of St. Lawrence, by G. S. Brady, is contained in the Canadian Naturalist, No. 4 of Vol. V. It includes notices of 29 species, 5 of which are illustrated by 13 figures.

6. *On the early stages of Terebratulina septentrionalis*, by Edward S. Morse, Ph.D. 12 pp. 4to, with two plates. A paper showing careful research, from the Memoirs of the Boston Society of Natural History, Vol. II, Part I, No. II.

7. *Glacier Scratches along valleys.* (Appendix to Art. XXXII.)—Prof. Emmons, in his N. Y. Geological Report (1842) at page 422, says that the direction of the glacier scratches in northeastern New York "conforms to that of the great valleys; in the Champlain valley it is north and south; in the St. Lawrence valley, southwest." The particular localities where his observations were made are not mentioned. He describes deep and broad channelings of the Trenton limestone west of Watertown, on Black River, which have a southwest course, and extending to the shore of Lake Ontario, a distance of ten miles; and states that the scorings of the rocks are parallel to the valleys, which here run southwest. Among western observations on this point not published in this Journal, are those of Prof. C. A. White in his Iowa Report, and those of Dr. Newberry.

8. *Anthers of Parnassia.*—In the Journal of the Linnean Society, vol. xi, Mr. A. W. Bennett published, two or three years ago, an interesting article upon *Parnassia*, its structure, affinities, and its mode of fertilization. I am now to remark only upon its anthers, which are generally described as extrorse. Mr. Bennett, observing that the present writer, in the Genera of North American Plants Illustrated, describes the anthers as introrse, and gives a drawing of *P. Caroliniana* as an illustration, proceeds to say: "I do not, however, find any other observer to agree with Professor Gray's observation in this respect, except two American botanists, Dr. Torrey and Mr. Chapman, who have probably borrowed their descriptions from him; nor do any specimens which I have been able to examine of this species confirm any departure in this respect from the ordinary type of the genus."

It is easy to show that Dr. Torrey's observation, at least, is independent and original. In his Flora of Northern and Middle States, published in 1824, p. 326, he described the anthers of *P. Caroliniana* as "incumbent;" in his New York State Flora, 1843, as "fixed by the base, introrse." The first volume of the Genera N. Amer. Illustrated appeared in 1848. This season I have, for the first time, had the good fortune to see both *P. palustris* and *P. Caroliniana* in flower, in the Botanic Garden of Harvard University, the former blossoming at the beginning, the latter at the close of August. The difference between the two species "in this respect" is obvious.

In *P. palustris*, the anthers are certainly extrorse as to insertion; but the line of dehiscence lateral, with introrse rather than extrorse tendency.

In *P. Caroliniana*, the anthers are quite as much introrse as extrorse as to insertion, and truly introrse for dehiscence. A transverse section removes all doubt, showing the connective or solid part to be posterior, and the anther to be as truly introrse as possible. A. G.

9. *Journal of the Linnean Society* (*Botany*), No. 65, commencing the 13th volume, contains several papers of some interest. Dr. Hance, of Canton, has discovered and describes the plant the root of which is the Lesser Galingal, an export from southern China. He makes it a new species of *Alpinia*, *A. officinarum* Hance, but very near Roxburgh's *A. calcarata.* It appears that the export of it is increasing: 112,000 pounds, valued at £478, left China in the year 1867; nearly 178,000 pounds in 1868; and 370,800 pounds, valued at £3047, in 1869. Dr. Hance also contributes an article on the Chinese Silk-worm Oaks: he concludes "that all circumstances would seem to conspire to render the culture of the oak silk-worm in Europe a sure matter of success, if properly set on foot and fostered." Mr. Hanbury contributes Historical Notes on the *Radix Galangæ* of Pharmacy; from which it appears that its introduction into Europe was due to the Arabs. Although the drug has lost the important place which it once held in medicine, being merely an aromatic stimulant, which might take the place of ginger, yet it is still largely consumed,

specially in Russia, where it is used for flavoring the *liqueur* called *nastvika*, as a cattle-medicine, and by the Tartars it is taken with tea.

Dr. Masters gives a Note on the Genus *Byrsanthus* Guill., and ts floral conformation, suggesting an explanation of the singular arrangement of the glands and stamens, and indicating that two species have been confounded.

Rev. S. Matier discourses on Tamil Popular Names of Plants.

The brothers Tulasne contribute New Notes upon the *Tremellineous Fungi* and their Analogues, dating from the Western Coast of France in December last.

Mr. Neale contributes from S. Africa four papers, three of them upon certain Orchids and their Fertilization, and one upon the mode in which certain *Asclepiadeæ* are fertilized. The details are curious, but can hardly be condensed into an abstract.

Mr. Bentham, President of the Society, concludes the number with his paper on the styles of Australian *Proteaceæ;* illustrated by two plates. The flowers, seemingly arranged for self-fertilization, are really adapted for crossing, in some by a sort of dichogamy, the stigma being immature at the time when the pullen is deposited just around it; in others the stigma is curiously and variously protected or kept out of the way of the anthers (sometimes through the agency of a castrated stamen) until after the pallen of that flower is all shed. A. G.

III. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Twentieth Meeting of the American Association for the Advancement of Science, held at Indianapolis, Indiana, August* 16–21, 1871.—The satisfactory result of the Chicago meeting of the American Association in 1868, had, no doubt, its influence in deciding the choice of Indianapolis as the place for holding the recent session. The result seems on the whole to have justified the expectations of those who advocated the claims of the capital of the State of Indiana for this annual Congress of Science. The number in attendance is stated to have been about 200, or about the same as at Troy, Salem, and Chicago. The titles of papers entered are fewer, having been 78, against 143 at Troy, and 150 each at Salem and Chicago.

The Indianapolis meeting, under the presidency of Dr. Asa Gray of Cambridge, appears to have given much satisfaction to those present, among whom were many distinguished workers in science. His Excellency Governor Baker welcomed the Association to the hospitalities of Indianapolis and of the State of Indiana in a cordial opening speech, to which the retiring President, Dr. T. Sterry Hunt, replied in his usual appropriate and graceful manner.

The formal address of the retiring President was delivered on the evening of the first day, before a large audience. Its subject, "The Geognosy of the Appalachians and the origin of Crystalline Rocks," and its general scope, are stated on page 205.

An interesting feature of the Indianapolis meeting was an excursion on a grand scale to the coal fields of Indiana. The excursionists, numbering over four hundred, were carried in eight coaches. They visited at Knightsville the iron furnaces of the Watson Brothers, where they were sumptuously entertained at luncheon; also three other iron furnaces and several coal mines on the way to the town of Brazil, where they were welcomed by the citizens at Masonic Hall and dined with the usual complimentary addresses on both sides. The recent development of the coal known as block coal, due largely to the intelligent zeal of Prof. E. T. Cox, the State Geologist of Indiana, was the object of greatest scientific interest in the excursion. This coal is used in the raw state in the iron furnaces, and is said to be remarkably free from both sulphur and phosphorus. The excursion rested at Terre Haute, a town of 20,000 inhabitants, which seems to have exhausted every means to render the visit of the Association delightful and profitable. Here they passed the night, holding an evening general session at the Opera House. A popular lecture on the Winged Reptiles was delivered by Mr. A. Waterhouse Hawkins. On the following morning Dr. Gray delivered a lecture on the Fertilization of Flowers by Insects to a delighted audience; and after an early dinner, the party returned by special train to Indianapolis.

An excursion to Mammoth Cave in Kentucky was the closing act of the Association, after the adjournment of the Indianapolis meeting.

The Association, after enjoying the public and private hospitalities of Indianapolis and of the sections of the State included in the excursions, adjourned on the 21st, having voted conditionally to meet in San Francisco, California, in July, 1872, the final decision having been left with the Standing Committee.

The officers chosen for the next meeting are: President, Dr. J. LAWRENCE SMITH, of Louisville, Ky.; Vice-President, Prof. ALEX. WINCHELL, of Ann Arbor, Mich.; Permanent Sec'y, Prof. JOSEPH LOVERING, of Cambridge, Mass.; General Sec'y, Prof. E. S. MORSE, of Salem, Mass.; Treasurer, WILLIAM S. VAUX, of Philadelphia.

The following are the subjects of the papers presented, and of the public lectures:

1. IN GENERAL SESSION.

1. On Pterosauria; by B. Waterhouse Hawkins.
2. Fertilization of Flowers by Insect Agency; by Asa Gray.
3. On true Musical Intonation; by J. D. Tillman.
4. The Earthquake of October, 1870; by Charles Whittlesey.
5. On the Iron and Coal Interest of Indiana; by T. Sterry Hunt.
6. An Examination into the Laws of Development of Organic Types; by E. D. Cope.

2. IN SECTION A.—*Mathematics, Physics, and Chemistry.*

1. The Daily Motion of a Brick Tower caused by Solar Heat; by C. G. Rockwood.
2. On the use of the Zenith Telescope for determination of Time; by J. E. Hilgard.

3. On the construction and verification of Metric Standards for the United tates; by J. E. Hilgard.
4. Organic Identity of the Albumen and Endopleura of Seeds; by T. C. Hilgard
5. The Influence of the Moon on the Crust of the Earth; by Clinton Roosevelt.
6. On Chemical Equivalents; by S. D. Tillman.
7. On the Transmission of Heat; by S. D. Tillman.
8. The Relation between the Distances and proper Motions of the Stars; by T. L. Safford.
9. On the Earthquake of October, 1870; by Charles Whittlesey.
10. An inquiry concerning the Physical Relations between the Masses and Mean Distances of the Minor Planets; by Daniel Kirkwood.
11. On the Distribution of the Mean Distances of the Minor Planets; by Daniel Kirkwood.
12. Note on the Periodicity of the Solar Spots; by Daniel Kirkwood.
13. On the probable age of Halley's Comet; by Daniel Kirkwood.
14. Longitude Determination across the Continent; by George W. Dean.
15. On the Mutual Action of Electric Currents; by E. B. Elliott.
16. Radiation; by H. F. Walling.
17. The Chemical Equivalent of Æther; by H. F. Walling.
18. The co-relation of Electricity and Chemical Force; by H. F. Walling.
19. On a form of Boomerang in use among the Mogni Puebla Indians of North America; by C. C. Parry.
20. An improvement of Eggertz's Method of determining Carbon in Steel; by E. R. Taylor.
21. The Four Great Eras in Modern Astronomy; by Jacob Ennis.
22. Meteors; by Jacob Ennis.
23. The cause of Stellar Heat and Light; by Jacob Ennis.
24. The Character and Chemical Composition of the Meteorite that fell on May 21, near Searsmont, Maine; by J. Lawrence Smith.
25. A description of the exact locality of the immense masses of Meteoric Iron in Cohahuila, Mexico, with the analysis of one recently discovered; by J. Lawrence Smith.
26. A convenient and certain method of regulating a constant level of Water in the water baths of a Laboratory; by J. Lawrence Smith.
27. Remarks on the Cinnabar and other Minerals from California; by J. Lawrence Smith.
28. A new and ready method of making Platinum black; by J. Lawrence Smith.
29. A ready method of separating the Alkalies, on a large scale, from Lepidolite; by J. Lawrence Smith.
30. A new and convenient Specific Gravity Flask; by J. Lawrence Smith.
31. On the Enharmonic Scale of 31 tones in the octave, and a new practical key-board corresponding with the accepted musical notation; by P. H. Van der Weyde.
32. On Oblique Microscopic Examination, and a new, simple apparatus for the same; by P. H. Van der Weyde.
33. On the use of the Balance for determining the changes in Atmospheric Pressure, and the co-efficient of Barometric Correctness; by P. H. Van der Weyde.
34. On the Invisible Caloric Extreme of the Solar Spectrum, and the non-caloric lines or bands in the same; by P. H. Van der Weyde.
35. On a new and more perfect fire test of illuminating Petroleum, without the use of fire; by P. H. Van der Weyde.
36. An application of an exponential function; by J. E. Hilgard.
37. To find a general formula for the length of "Curves of Pursuit;" by Joseph Ficklin.
38. Steam boiler Water and Incrustation; by Jos. G. Rogers.

3. IN SECTION B.—*Geology and Natural History.*

1. The Monocotyledon the Universal Type of Seeds; by Thomas Meehan.
2. The Classification of Echinoderms from their Microscopic Structure; by Alexander Agassiz.
3. Mechanism of Flexion and Extension in Birds' Wings; by Elliot Coues.

4. On the Morphology of the Osseous System; by T. C. Hilgard.
5. On the Geological History of the Mexican Gulf; by E. W. Hilgard.
6. Observations on the Common Ground Worm; by James J. H. Gregory.
7. Observations on the Geology, Physical Features, and Retrocession of Niagar Falls; by George W. Holley.
8. Some Questions on Surface Geology; by Frank H. Bradley.
9. On the Entozooa peculiar to Swine; by William B. Fletcher.
10. On the Development of the Tarsal and Carpal Bones in Birds; by Edward S Morse.
11. On the Characteristics of the Primary Groups of the Class of Mammals; b Theodore Gill.
12. On the Natural System of Fishes; by Edward D. Cope.
13. The Embryology of Chrysopa, and its bearings on the classification of th Neuroptera; by A. S. Packard, Jr.
14. On the Eozoon Canadense in the Crystalline Limestones of Massachusetts by L. S. Burbank.
15. On the relation of Anomia; by Edward S. Morse.
16. Contributions to Physiographic and Dynamical Geology; by Richard Owen
17. On the apparently one-ranked phyllotaxis of Baptisia perfoliata, and on th phyllotaxis of Cucurbitacea; by Henry W. Ravenel.
18. On the Geology of Northwestern Massachusetts; by Sanborn Tenney.
19. Western Coal Measures and Indiana Coals; by E. T. Cox.
20. Remarks on the Geology of the Mississippi Bottom; E. A. Smith.
21. Account of a Dust Storm which occurred in Clinton county, Indiana, Dec 24, 1870; by Joseph Tingley.
22. Remarks upon the Cattskill Red Sandstone Group as it occurs upon the borders of New York and Pennsylvania; by James Hall.
23. Views of Nature: of the Organizing Principle, and of Life and Intellect; b E. C. Seaman.
24. Vitalism, Spiritualism, and Materialism; by E. C. Seaman.
25. The Eozoon Limestone of Eastern Massachusetts; by J. B. Perry.
26. Remarks on the Geological Map and Section of Missouri Rocks; by G. C Swallow.
27. On the Extinct Tortoises of the New Jersey Cretaceons; by Edward D. Cope
28. Remark on the Abies Douglassii, and a new species, or a peculiar variety o the Abies balsamifera, of the Rocky Mountains; by G. C. Swallow.
29. Remarks on the Snow Line in the Mountains of Montana; by G. C. Swallow
30. On the Embryology of Amblystoma lurida of Sager; by P. R. Hoy.

In Subsection E.—*Archeology and Ethnology.*

1. A Theory on the Nature of the Difference in the Mental Capacity of High an Low Races of Men; by Renas Davis.
2. Note on the Distribution of Population in the United States; by J. E. Hilgard
3. Rock Inscriptions in Ohio; by Charles Whittlesey.
4. An Ancient Mount on the Etowah River, Georgia; by Charles Whittlesey.

On the rates of interest realized to investors in the Securities of the Unite States; by E. B. Elliott.

Law:—What is it, and what are its Functions and Limits; by E. C. Seaman.

In Subsection C.—*Microscopy.*

1. Report on Photographing Histological Preparations by Sunlight; by J. J Woodward.
2. Remarks on a new form of Achromatic Condenser, applicable to low and medium powers; by E. Bicknell.
3. On a new form of Micro-Telescope; by R. H. Ward.
4. Remarks on recent improvements in Achromatic Condensers; by R. H. Ward
5. On the use of the Microscope in Chemical Analysis; by P. H. Van der Weyde
6. On the observation of the Electric Induction Spark by the Micro-Spectroscope
7. On Oblique Microscopic Illumination, and a new, simple Apparatus for th same; by P. H. Van der Weyde.

8. On some observed changes in Vorticella; by A. H. Tuttle.
9. Remarks on a Standard of Powers for Microscopical Objectives and Eye Pieces; by R. H. Ward.
0. On the Microscopic Structure of Eozoon Canadense; by E. Bicknell.

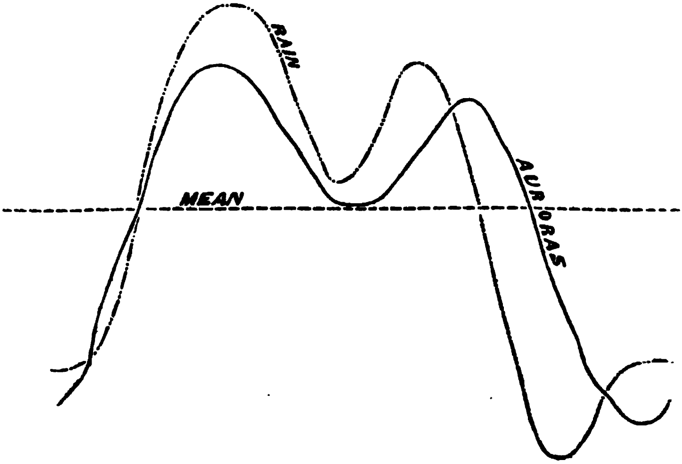
3. *On the relation of the Auroras to Gravitating Currents;* by LINY EARLE CHASE, Professor of Physics in Haverford College. Read before the American Philosophical Society, May 5th, 1871.) –Prof. Loomis's observations of the number of auroras in each ionth of 1869 and 1870 (Amer. Jour. of Science, III, S., i. 309), are pecially noteworthy, both because of the careful accuracy of the bserver, and because they are the first published observations rhich furnish satisfactory data for an approximate determination f the laws of auroral distribution.

If the auroras are, as is now generally believed, luminous maniestations of terrestrial magnetism, it seems reasonable to look to hem for some additional evidence upon the question of the relaon between magnetic and gravitating currents. Messrs. Baxndell and Bloxam have already pointed out some resemblances etween hyetal and magnetic curves (see Proc. A. P. S., x, 368), nd if analogous resemblances can be traced between hyetal and uroral curves, they will be interesting and suggestive.

I have not found the similarity between the annual distribution f rain-falls and of auroras sufficiently striking to impress any one ho has not made a special study of the causes of resemblance and ifference. But, as I have repeatedly urged, currents are subject an increased number of disguising disturbances, in proportion the sluggishness of their motion, and the time which is conseuently required for their formation or change. We may very asonably look for analogies between the daily and the annual uroral or magnetic curves, of a character for which we could hope find no parallel in wind, rain, or ocean-current curves.

If we desire, therefore, to find evidence of the joint influence of lar expansion and gravitating equilibrium, we should look where is most likely to be found, and to the best of the observations hich may be supposed to be fairly comparable. There are simr variations of solar attitude, and consequently increasing and minishing solar force, in the day and in the year, but the effects these variations upon the precipitation of vapor, are more likely be shown in their greatest simplicity by the means of observans at different hours of the day than at different seasons of the ar. I know of no published observations of this character at ew Haven, but there are some extending over a long series of ars at Philadelphia, and at Greenwich, the curves at each stan indicating minima of rainfall at noon and midnight, and maxa in the morning and evening. The difference of longitude beeen Philadelphia and New Haven being less than 2½°, it is not ely that there is any material difference in the daily rain-curves the two places.

In order to make the curves fairly comparable, both in regard the times and the magnitudes of deviation, I treated the auroral observations in the same manner as those of rainfall (Proc. A. P. S., x, 526). Both in the magnetic and in the hyetal phenomena, the greatest effects accompany the greatest atmospheric changes. But in the magnetic disturbances the principal maxima occur i the spring of the year and the morning of the day, while the general evaporation is increasing, whereas, in the daily rains at Philadelphia, the principal maximum occurs in the afternoon, whe evaporation is diminishing. I have, therefore, compared the midwinter ordinate of the auroral with the noon ordinate of the rai curve, and the midsummer auroral with the midnight hyetal ordinate.



The auroral observations and the normal ordinates, of the accompanying curves, are given in the following table. I presume n one will doubt that the condensation of vapor, which is represented by the rain curve, is occasioned by the simple operation o gravitation in blending currents of different temperatures, and see no reason for postulating any different law for the developmen of electricity and magnetism in the aurora.

Comparative Table of Auroras and Rainfalls.

Months.	No. of Auroras.	Normals.	Hours.	Normals of Rain.	Months.	No. of Auroras.	Normals.	Hours.	Normals of Rain.
January	32	88	0	91	July	38	100	12	10
		90	1	91			101	13	10
February	31	94	2	93	August	34	103	14	10
		98	3	98			105	15	10
March	41	103	4	105	September	43	107	16	10
		107	5	110			106	17	9
April	44	109	6	113	October	38	103	18	9
		109	7	113			100	19	9
May	36	108	8	112	November	27	95	20	8
		106	9	109			91	21	8
June	31	103	10	105	December	30	89	22	9
		101	11	102			87	23	91

IV. MISCELLANEOUS BIBLIOGRAPHY.

1. *War and the Weather, or the Artificial production of Rain;* by EDWARD POWERS, C.E.—The object of this little volume is to show that rain can be produced by human agency, particularly by heavy discharges of artillery; and a large number of cases are cited in which great battles have been followed by speedy rain. Six cases of this kind are cited which occurred during our war with Mexico in 1846 and '47; nine cases of battles or skirmishes are cited which occurred in 1861 in the war of the rebellion, and which were followed by rain at no great interval; forty such cases re cited for 1862; thirty for 1863; twenty-eight for 1864; and ix for 1865. Eighteen similar cases are also cited from among he great battles which have occurred in Europe during the past entury, making a total of 137 cases. The author thinks that if hese facts are insufficient to convince, it would be vain to expect o do so with a greater number of cases.

To this argument it may be replied that throughout the region rom which his examples are mainly collected, rain falls upon an verage once in three days, and probably a little more frequently; o that from the conclusion of one rain to the commencement of nother, the interval is on an average but little over two days. ow battles are not usually commenced during a period of rain; enerally not till some hours after the conclusion of a rain. Rain ught then generally to be expected within about one day after e conclusion of a battle. Now the argument of Mr. Powers is me in this point. He takes no precise account of the length of e interval between the conclusion of a battle and the commence-ent of rain; nor does he show that this interval is less than it ould be if the battle had no influence in the production of the in; and in particular he takes no account of the cases unfavorable his theory, in which rain follows a battle only after a very long terval. In order to make the argument complete, a much more reful analysis of the facts is required. It should be determined m a comparison of a large number of cases, including *all* the ttles within a particular circuit, what is the average interval tween a battle and the next succeeding rain, and it must then be own that this interval is less than it would be if the battle had influence in the production of rain.

The simplest mode of making the comparison may be the follow-g: Determine for *all* the battles occurring within a particular cuit what is the average interval between the conclusion of the n next preceding a battle and the commencement of the rain t following it; and then determine for the same region the rage interval between two successive rains when no battle has urred. If the former interval should be found sensibly less n the latter, it would be reasonable to conclude that the battle l exerted some influence in accelerating the fall of rain. The ts collected by Mr. Powers are not digested in any such manner; l although we are inclined to the opinion that great battles do rt some influence in the production of rain, we do not think that Mr. Powers has established his proposition in a satisfactor manner.

With regard to the mode in which a heavy discharge of artiller might cause rain, we differ widely in opinion from the author c this book; but we are not fairly called upon to assign a reason *wh* artillery firing causes rain until it has been shown that it *does*, a least sometimes, produce such an effect. We should be muc pleased if Mr. Powers, or some other person, would resume th discussion of this subject in accordance with a truly scientifi method. E. L.

2. *Introductory Text-Book of Meteorology*; by ALEXANDE BUCHAN, M.A., F.R.S.E., Secretary of the Scottish Meteorologic Society. 218 pp. 12mo, with 6 plates. Edinburgh and Londo 1870. (Wm. Blackwood & Sons).—Mr. Buchan takes the lea among the meteorologists and meteorological investigators c Scotland. This small and convenient text-book takes up in orde the history and scope of Meteorology; Atmospheric pressure an its distribution over the globe—a subject which has been muc elucidated through Mr. Buchan's labors; modes of observing an calculating temperature; solar and terrestrial radiation; distribution of terrestrial temperature and its relation to atmospheri pressure; moisture of the atmosphere; mists, fogs and clouds rain, snow and hail; winds; storms; atmospheric electricity whirlwinds, and waterspouts; aurora borealis and terrestrial magnetism; ozone; optical phenomena; meteors; weather and stor warnings. Six of the plates contain an exhibition for the glob of the isobarometric and isothermal lines; one is a synchronou weather-chart of Europe for 2d Nov., 1863, at 8 A. M., and one similar chart of the West Indies for 1st Oct., 1866, at 8 P. M.

3. *Dominican Republic. Report of the Commission of I quiry to Santo Domingo*, with the Introductory Message of th President, Special Reports made to the Commission, State Pape furnished by the Dominican Government, and the statements over Seventy Witnesses: *Commissioners*, B. F. WADE Presiden A. D. WHITE, S. G. HOWE; Secretary, A. A. BURTON, Assista Secretary, F. DOUGLASS. 298 pp. 8vo, with a map of the islan This volume contains reports from the Scientific view of th expedition, W. P. Blake, C. Wright and others. But the time the island was too short for thorough exploration.

4. *Sun-Pictures of Rocky Mountain Scenery*, with a descri tion of the Geographical and Geological features and some accou of the Resources of the great West; containing thirty phot graphic views along the line of the Pacific Railroad, from Omah to Sacramento. By F. V. HAYDEN, M.D., U. S. Geologist, Pro Min. and Geol. in the University of Pennsylvania. 150 pp. 4t 1870. New York: (Julius Bien). The character of this wor has already been stated in this Journal, and citations have bee made from its pages of important scientific observations. It i published in elegant style, the paper and printing being of th best kind; and the photographs excellent and highly interestin

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Art. XXXIX.—*On some Phenomena of Binocular Vision;* by Joseph LeConte, Prof. Geol. and Nat. Hist., University of California.*

VI. *So-called "images of illusion;" and the theory of binocular relief.*

In a very elaborate paper on binocular vision published in the Archives des Sciences† for Feb., 1871, which is itself but a succinct resumé of a much more extended memoir soon to be published, M. Pictet undertakes to establish on a firm basis the "*nativistic*" theory which regards *corresponding points* as *congenital* and the result of *anatomical structure*, as opposed to the "*empiristic*" theory which regards them as the *result of experience*. After summing up the usual arguments and objections on each side, he proceeds, as he thinks, to prove the truth of the former theory by showing, first, *a priori*, the consequences which must flow from the admission of this theory; second, that the visual results of certain experiments are precisely what *a priori* reasoning leads us to expect; and third, that this theory, in the form in which he maintains it, explains all the more obvious phenomena of binocular vision.

The one strikingly new thought in M. Pictet's memoir is the supposed existence of "*images of illusion*" in every act of vision. *This* it is which follows, he thinks, from the admission of the nativistic theory; it is *this* which he attempts to prove by all his experiments; it is by means of *this* that he solves all the vexed questions of binocular vision. Now while I believe the evidence is overwhelmingly in favor of the nativistic theory, i. e., the *congenital* existence of corresponding points, yet I feel perfectly confident that the existence of M. Pictet's images of illusion, from their very nature, cannot be proved; and that all the phenomena which he adduces as proof may be easily explained by the known laws of binocular vision. Passing over, therefore, the many interesting questions touched upon in M. Pictet's very suggestive paper, I will confine myself wholly to M. Pictet's *illusive images;* my sole object being to rescue the theory of binocular vision from the confusion into which it has been thrown by the introduction of this new idea.

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* For previous papers on this subject see II, vol. xlvii, pp. 68, 153; III, vol. i, p. 33, and vol. ii, p. 1.

† Arch. des Scien., nouv. per tome xl, p. 105.

In order to account for single vision with two eyes, Müller supposed that the nerve fibers which terminate *peripherally* in identical points of the retinæ (*corresponding fibers*) are *centrally* fused into *one fiber*, or *terminate centrally in one brain cell.* M. Pictet admits that the nativistic theory is by no means dependent on this assumption—the existence of corresponding or identical points as a congenital fact, by whatsoever structural contrivance effected, being all that is contemplated by this theory—yet all his reasonings are based upon, and all his experiments are intended to prove, *an alliance* between corresponding fibers *equivalent to* the *fusion* of Müller. For M. Pictet, corresponding fibers under all conceivable circumstances behave *like*, and therefore *are* substantially, a *single bifurcating fiber.* Assuming, then, an anatomical structure equivalent to fusion of corresponding fibers into one in the brain, M. Pictet proceeds to show that, by the well-known physiological law which refers all impressions on the nerve *centers* to the *peripheral extremities of the nerve fibers*, an impression made upon any point of *one retina*, being carried to the brain, would thence be necessarily referred back to *both extremities* of the bifurcating fiber, i. e., *to corresponding points of both retinæ.* Therefore, if luminous rays from an object impress the *retina of one eye*, the impression transmitted to the brain must be referred back *equally to both eyes*, producing *two identical external images* in the field of view; the one a *true image* produced by the luminous impression on the retina of one eye, the other an "*image of illusion*"—a subjective or spectral image—*reflected* from the *point of alliance* within the brain to the *retina of the other eye.* According to M. Pictet, therefore, even *when we shut one eye* we still, in a certain sense, *see objects with both eyes;* for there is a true image belonging to the open eye and an illusive image to the closed eye. These two images are *identical* and seen at the *same place.* Stereoscopic effects are not observable in monocular vision only because these two images are *perfectly identical* and *perfectly united.*

It is easy to see, from the perfect identity and the inseparable union of the true and illusive images, how difficult, nay, even *mpossible* and therefore futile, to attempt to prove the existence of the latter. Nevertheless, M. Pictet details several experiments which, he thinks, prove beyond doubt the existence of uch illusive images in every act of vision. I wish to show that he phenomena of M. Pictet's experiments may be explained vithout resorting to illusive images. Before doing so, however, find it necessary to state very concisely certain general principles of binocular vision which I shall use in their explanation, eferring the reader to my previous papers for a fuller statement nd proof. Throughout this paper I shall refer back to these rinciples by means of the numerals affixed.

1. The impressions produced by *luminous retinal images* are ransmitted to the brain and, by a psychological law, are proected outward into the external world and seen there as *exteral images.* Each eye has its *own field of view* crowded with *its wn images.* As these images are usually seen *double*, it will ften be convenient to regard them not as *objects* but as external *nages*, the signs of objects. Only when the two images formed y the same object are superposed do we see the object *single* nd *in its true position.* This takes place when the *luminous* nages fall on *corresponding points.* The two retinal images on orresponding points are *seen* externally as a *single* image or bject. It is true this may be regarded as *really a single image* –*the sign of the fusion of the nerve fibers.* But since we can move bout the *two* images of the *same* object, bring them near toether, unite them partly or unite them wholly, as we please; nd since, moreover, we can even take images of *different* objects nd superpose them, and if they be similar, unite them so as to ppear as *one* object, it is better, because it more easily explains isual phenomena, to regard single binocular vision as the result f the *superposition of two images.*

2. In binocular vision with the optic axis parallel, as in azing at a distant object, the whole field of view and all objects the field, including the visible parts of the face, are shifted y the *right* eye a half interocular space to the *left*, and by the ft eye the same distance to the right, without altering the relive position of·parts; so that the two eyes and their visual nes seem to unite to form a *single binocular eye*, and a *single iddle visual line* along which the eye seems to look. Any line, d or plane in the median line, as also the nose itself, is *doubled teronymously*, and becomes two lines, rods or planes, parallel each other, and separated by a space exactly equal to the terocular space. Between the two noses and between the two rallel lines, rods or planes, the combined eyes seem to look t along the combined visual lines upon the distant object.

Of course, by this shifting of the two fields all objects are similarly doubled.

Thus in binocular vision the two eyes *seem* actually to be superposed and corresponding points to coincide. This apparent combination of the eyes and their visual lines is the necessary result of the existence of corresponding points. Images on corresponding points are seen single; all objects in the two visual lines must impress corresponding points; therefore the visual lines themselves, if they were visible lines, would be seen single. This can take place only by combining to form a single *middle* visual line.

3. In turning the eyes in any direction *without altering their convergence* objects seem stationary, and the visual lines seem to move and sweep over them. But when we turn the two eyes in *opposite directions*, as in strong convergence, then the *visual lines seem stationary* (i. e., we seem to look in the same direction), and *all objects or rather images seem to move in a direction contrary to the actual motion of the eye;* the whole field of view of each eye with all its images rotates about the optic center in a direction contrary to the rotation of the eye. This is plainly seen by voluntarily and strongly converging the eyes upon an imaginary point near at hand, and at the same time watching the movements of the more distant images. The whole field of view of the right eye with all its images will be seen to rotate to the right and of the left eye to the left, i. e., *homonymously.* The images of all objects as they are swept successively by the visual lines of the two eyes are brought successively in front and superposed. If we could turn our eyes outward, the fields and their images would move heteronymously. This is seen to a limited extent in the act of falling to sleep.* Even with the two eyes *turned outward*, therefore, the two visual lines are united *in front*, and objects on the visual lines are brought in front and superposed. This is the necessary result of the properties of corresponding points; but I have also proved it by observations made upon persons whose eyes in a perfectly passive state turned slightly outward.*

Thus, there are two *apparent* movements of the visual fields accomplished by the eyes in binocular vision: 1st, a *shifting* of each field *heteronymously* a half interocular space; this is involuntary and habitual, and would of itself double all objects heteronymously; 2d, in ocular convergence, a *rotation* of each field about the optic center *homonymously.* The necessary consequences of these movements are: (a) that the two images of *an object at the point of sight* are superposed and the object is seen single; objects on *this side* the point of sight are doubled heteronymously, while objects beyond the point of sight are doubled homonymously; (b) that all objects (*different objects*) lying in the visual lines, whether on this side or beyond the point of sight, have two of their images (one of each) superposed; so that the two visual lines *under all circumstances* are combined to form a binocular visual line passing from the combined eyes, through the point of sight, and onward to infinite distance.

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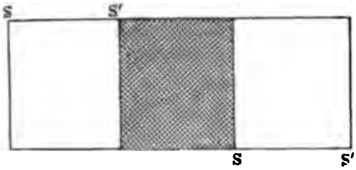
* The proof of this statement I hope to give shortly in a separate article.

Let us now, in the light of these facts, examine M. Pictet's experiments. I will pass over for the present what he seems to regard as his crucial experiments, and take up first the general phenomena of double images, as a proper understanding of the nature of these will make all that follows clear.

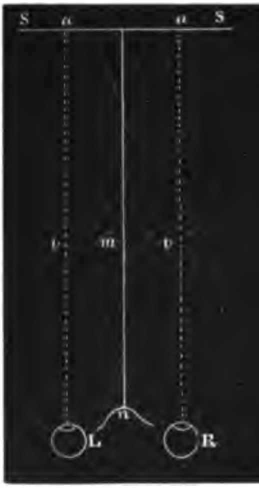
If we hold up a finger before the eyes, and gaze at the wall on the opposite side of the room, two heteronymous images of the finger will be seen separated by a space nearly equal to the interocular space. As a question of geometry this is sufficiently explained by the different parallactic position of the finger as seen by the two eyes; as a question of binocular vision, by the shifting of the fields of view of the two eyes heteronymously as already explained (2).

But the images are *transparent.* M. Pictet lays much stress on this. It is, he says, "an essential point which we have not found in works on optical physiology" (p. 105). He explains it as follows: There is a part of the wall which sends no luminous rays to the right eye (viz: that covered by the right-eye image); but this part impresses the left eye, and this impression is *propagated* to the right eye, and perceived by it at the same place as an *illusive image.* The finger, therefore, will appear transparent to the right eye because by means of an illusive image the wall is seen behind it. The same explanation of course applies to the left-eye image of the finger, which is transparent, according to M. Pictet, because the left eye sees the wall behind it by means of an illusive image propagated from the right eye. Now *our* explanation is entirely different; and we cannot but think that the transparency of double images have been so little noticed by writers only because their explanation seemed so obvious. Our explanation is as follows: We see *every* part of the wall because *no* part is concealed from *both* eyes. The images must seem transparent since they conceal nothing from *the observer.* M. Pictet would say the right-eye image conceals nothing from the right eye, and the left-eye image nothing from the left eye, and therefore the parts covered by these images must be seen, by the corresponding eye, by means of illusive images; but *we* say, a part of the wall *is* concealed from the right eye (viz: that upon which the right-eye image falls), but this part is visible to the left eye; similarly, a part of the wall *is* concealed from the left eye, but this part is visible to the right. M. Pictet says, every part of the wall is seen by *each* eye, either by true or by illusive images; we say, every part of the wall is seen, not by each eye, but by the *binocular observer;* not some parts by true and some by illusive images, but only by *true images.*

1.



2.



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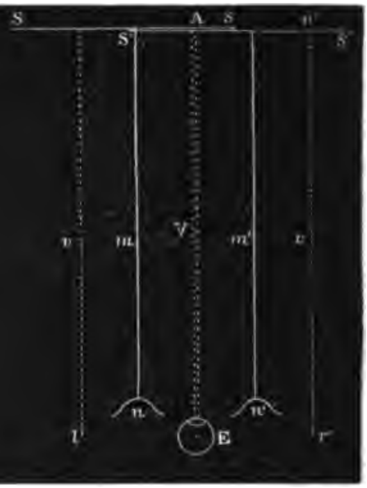
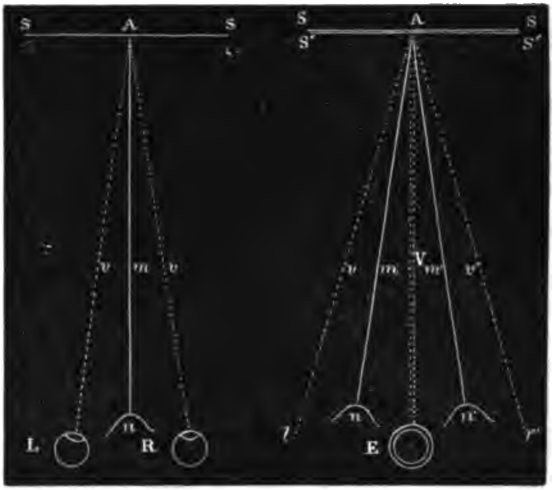


If instead of a finger we use a screen several inches wide (wider than the interocular space), then the double images will not entirely separate. They will slide over each other heteronymously through a space equal to the interocular space (2). The overlapping area will be opaque because it covers a portion of the wall concealed from both eyes; the rest will be transparent. The visual result is represented by fig. 1, in which S S is the right-eye image of the screen, S′ S′ the left-eye image, and S′ S the overlapping area. These facts are more completely represented by my method in figs. 2 and 3, of which fig. 2 represents the actual relation of parts, and fig. 3 the visual result. In fig. 2, R and L are the right and left eye respectively, *n* the nose, *m* the median line, *v v* the visual lines, S S the screen. Fig. 3 will readily explain itself if the reader will call to mind that in all my figures representing visual results capitals represent combined images, small italics right-eye images, and dashed italics left-eye images. If now the optic axes be gradually converged, as already explained (3), these heteronymous images will slide over each other homonymously, making the opaque area larger and larger, and the transparent margins smaller and smaller, until when the point of sight is at the screen, fig. 4, then the images will *completely unite*, and the screen become *entirely opaque*. This is shown in the visual result, fig. 5.

4. 5.

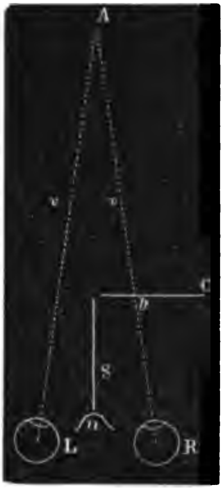


If next we use *two* fingers, one of each hand, and gaze again at the wall, we will see four images all transparent. Now approximate or separate the two fingers until the two middle images unite; we will have three images, the middle one *opaque*, the other two transparent. The reason is obvious. The middle one is opaque because a portion of the wall is concealed by it from *both eyes*. This portion of the wall is concealed from the right eye by the right finger, and from the left eye by the left finger; but it is the right-eye image of the right finger and the left-eye image of the left finger which unite to form the middle opaque image, while the right-eye image of the left finger is seen to the left, and the left-eye image of the right finger to the right, both *transparent*. In binocular vision, *superposed images* of opaque objects are *always opaque*, while *single images* are *always ransparent*.

The principles (1, 2, 3) laid down in the early part of this paper, together with the explanation of transparent double mages just given, furnish, we believe, the key to all M. Pictet's experiments. We will make the application only to those which he thinks most conclusive of the existence of illusive mages. We will first give his experiments and his conclusions s fairly as we can, and then will proceed to give our own explanation. The following experiments M. Pictet thinks conclusive:

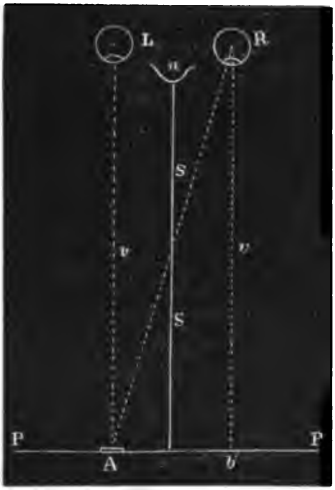
Place an opaque screen S (fig. 6) against the nose *n* in the *median plane of sight*, in such wise that the object A may be seen by both eyes. Now place a second screen C across the visual line A R of the right eye, so as to intercept rays from the object A to the right eye. Nevertheless, the object A will be seen *apparently* through the opaque screen C, which will therefore appear *transparent*, and may even be drawn in outline with accuracy on the screen at *b exactly where the visual line of the right eye pierces the screen*—exactly where, if the screen were transparent ground glass, we would see it with the right eye, and might trace its outline. M. Pictet thinks this absolutely inexplicable, except on the assumption that an illusive image is actually seen at A by the right eye; and that it is this that we draw in outline on the screen at *b*, the screen being transparent because the illusive image is seen beyond.

6.



But M. Pictet gives another experiment which he thinks still more conclusive. On a sheet of paper lying on the table place a piece of money; then place a screen upright on the right side of the money, and let the face of the observer be brought down upon the screen, so that the latter being in the median line *shall intercept the view of the right eye.* Nevertheless, says M. Pictet, "on directing the regard upon the piece of money, we see that the vertical screen appears transparent throughout, and that *it permits the right eye to distinguish the piece*, as if through a very diaphanous surface." "If now we give to the optic axes a direction more parallel, we see the image of illusion of the right eye move gradually toward the right, traverse the line of intersection of the screen and the table, and come to project itself on the other side upon the paper, where we may trace its outline correctly." To represent these facts more clearly I give the diagram, fig. 7. In this figure R and L are the two eyes, p p the sheet of paper, A the money in the direction of the visual line of the left eye, S S the median screen, A R the visual line of the right eye when we look at the piece of money A and seem to see it through the screen, R *b* the visual line of

7.



ıe right eye when the optic axes become parallel, and *b*, *exactly here the visual line of the right eye pierces the paper*, the place here the outline of the piece may be traced. The image .oves to the right or left according to the position of the optic ɛes, being always where the visual line pierces the paper. ut "the most advantageous position of the optic axes," says . Pictet, "is parallelism, for it is that which *removes the farthest e image of illusion from the real image.*" I wonder that M. ictet did not reflect that, being on corresponding points, by s own principle *the image of illusion*, if any, *cannot be separated om the real image;* and that *there is in fact but one image seen.*

But furthermore, if a convex lens be placed across the visual ıe of the right eye R *b*, the image at *b* will not be affected, but e *tracing* we make of the image will be found as much smaller an the money as the lens magnifies; showing that the image not magnified but the drawing is magnified, and therefore, M. ctet thinks, that the *image of the money is illusive or subjective, ile the image of the paper and of the tracing is real.* If, how- er, the lens be placed before the *left eye*, the image is magni- d because, thinks M. Pictet, this image is the *illusive right- e fac-simile of the magnified real image of the left eye.*

One more step of M. Pictet's proof. By keeping both eyes en, objects in the microscopic field may actually be drawn th accuracy on a sheet of paper placed on one side of the .croscopic tube. Or, still better, if a stereoscopic card, having ɔicture on one half and the other half blank, be placed in the ːreoscope, we may trace the picture on the blank half. Ac- rding to M. Pictet's view, the light impresses one eye, and .s impression is propagated as an illusive image to the other e, and thrown on the paper just where the visual line pierces it.

Such are the most important experiments upon which M. ɔtet bases his belief in the existence of illusive images. I ve been familiar with all these phenomena for many years; ıave also often used the method of tracing microscopic objects ommended by him; but my explanation is wholly different. M. Pictet's view be correct; and if in the experiments de- led we actually trace the outline of an *illusive image* belonging the right eye, then where is the *true image* belonging to the t eye? We see but *one image.* M. Pictet, in accordance h his principles (although he forgets them in the passage ɔted above), ought to answer, that being on corresponding nts the two images are perfectly *united.* Then why call the ıge we outline an image of illusion? The truth is, in every e, we *trace the outline of the true image seen by the left eye;* ıough by the principles laid down in the early portion of s paper, or by the properties of corresponding points, we .w the outline at *a different place* from the object.

[To be concluded.]

ART. XL.—*On the position and height of the elevated Plateau in which the Glacier of New England, in the Glacial era, had its origin;* by JAMES D. DANA.

THE existence of a region of high elevation in northern America as the source of a continental glacier in the Glacial era has often been assumed, but rather because the glacier theory was lame without it than as a result of special research with respect to the extent and location of such a region. I do not propose, at the present time, to treat the subject continentally, but simply to discuss the question as to the origin of the New England glacier. If I mistake not, however, the discussion, so far as it goes, meets the requirements of the continental question, while it proves that the idea of one central glacier source for the continent is without foundation.

1. *Position of the elevated plateau.*—In my paper of last month, on the "Valley Movements of Glaciers," (p. 233) I mentioned the fact, from the observations of the Vermont Geological Survey, that the glacial scratches on Camel's Hump, Mt. Mansfield and Jay's Peak, three of the high summits of the Green Mountains in the northern two-thirds of Vermont, have a course of about S. 50° E.* In the White Mountains, 70 miles to the south of east (S. 75° E.), the direction of the scratches near the Lake of the Clouds, on the north side of Mt. Monroe, is, as I am informed by Prof. C. H. Hitchcock, at points from 5000 to at least 5200 feet above the sea, in different places, S. 34° E. and S. 54° E. (S. 20° E. and S. 40° by compass); on the north side of Mt. Clinton, 4430 feet high, (one of the White Mountain series of summits about 17 miles west of Mt. Washington), near top, S. 50° E.–S. 54° E.; and on the south peak of Mount Clinton, at a level of 4320 feet, S. 54° E. He observes further that boulders occur at a height of 5800 feet on the north side of Mt. Washington.†

These scratches, and others crossing the Green Mountains, could not have been made with the land of North America at its present level. Elevated land must have existed to the north, if they were the work of glaciers. Moreover, these scratches a the higher summits of New England, must point approx-aately toward the region of elevated land, or the great Icy lateau, as we may call it, on whose slopes the movement of ie glacier originated.

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* According to the Vermont Geological Report the direction of the scratches on Camel's Hump is S. 50° E. (S. 40° E., compass), on Jay's Peak, S. 50° E., and on Mt. Mansfield, situated between the two, S. 30° E., S. 55° E., S. 58° E., at different points.

† Prof. Hitchcock observed also the course S. 24° E. near the Lake of the Clouds, but it was not common; also, in the saddle between Mt. Pleasant and Mt. Franklin, 4400 feet above the sea level, S. 34° E.; and the same in the gap between Mt. Pleasant and Mt. Clinton, 4050 feet high. It would therefore appear that the course of the general glacier over the White Mountain region was about S. 55° E., and that there were variations from this course due to the lay of the land.

This seat of power in the era of ice was not the Adiron-ıcks; for these stand (as will be seen on any map of North merica, and even a map of the World) much too far to the ›uth. The scratches point over Lake Champlain and the low lls and plains beyond, and across the St. Lawrence. On the her side of this river lies the large valley of the Ottawa, and it almost exactly in their direction; and the prevailing trend of e scratches through its lower half is about S. 45° E. Accord-g to the table in Logan's Report for 1863 (p. 890), this is the urse at Ottawa City, Hull, Rideau River at Stegman's Rapids, d Horton near Renfrew village south of the Ottawa. At llumettes Lake, the course S. 25° E. was found; but this cality is higher up the stream, and the course may well have en due to some local influence. There can be no doubt at, if the Glacial era was a *glacier* era, the Ottawa valley ice ıs a part of the same great ice-stream with that which crossed e Green Mountains, but a portion nearer the source.

The Ottawa valley, including that of Montreal River (which s the course of the Ottawa and is its western head-tributary), tends to a point nearly 500 miles in an air-line from Mt. ınsfield, and 570 from the White Mountains, with an average nd of S. 65° E. But the source of Montreal River was not source of the glacier movement; for the course of the atches in the Ottawa, instead of corresponding with the nd of the valley, is, as stated, S. 45° E. The scratches point, refore, to the eastward of the western source of the Ottawa, l at least as far east as the region northeast of Lake Temis-nang (the main source of the waters of the Ottawa), on watershed between the St. Lawrence valley and Hudson's y. The scratches of the White Mountains and Green Moun-ıs and those of the lower part of the Ottawa valley point ce toward this area.

t follows that the Icy Plateau, whence the great glacier took departure, must have existed either about this part of the ıadian watershed, or in the same direction farther to the north-st; and since the line of the scratches, if carried farther to northwest, would strike Hudson's Bay, or its western der, it is probable that this watershed was the actual ition.

This view accords with the great diversity of direction in scratches about Temiscamang Lake, they varying, accord-to Logan, from S. 78° E. to S. 7° W., the least easting ıg found on the *west* side of the Lake; the observations are, at East Bay, S. 53° E., S. 78° E.; on the east shore S. 38° E S. 18° E.; at West Bay, S. 15° E.; on the west shore, S. 35° E S. 18° E., S. 14° E., S. 1° E., S. 7° W.

The courses of the scratches on the heights of northern Main (S. 59° E. on Mt. Abraham, C. H. Hitchcock) also favors thi conclusion. Again, in the part of Canada, north of northeaster Maine, on the Madawaska River, about Temiscouata Lake Logan found scratches trending S. 54° E., S. 52° E., S. 55° E S. 66° E., S. 48° E., S. 60° E., (with one of S. 27° E.); and thes courses, if the form of the surface has not increased the easting would point to the same watershed and the part lying betwee Temiscamang and Mistissinny Lakes, but nearer the latter, and these lines continued would strike into Hudson's Bay, and thi is additional proof that the high land was along the watershed

Again, the courses of the scratches in western New Yor and on Lake Huron and Lake Nipissing (northeast of Lak Huron and south of Lake Temiscamang), have considerabl *westing.* On the north shore of Lake Huron the course i mostly S. 13°–22° W., according to Logan; on the Georgia Bay (northeastern side of Lake Huron), S. 37°–45° W.; a the southeast bay of Lake Nipissing, S. 35° W; in wester New York, S. 35° W., according to Hall. This prevalent *westing* points toward the same region northeast of Lake Temiscamang along the Canadian watershed, and seems to shut o from consideration regions farther north or west.

Taking into view all the observations here cited, we may conclude with much confidence that the region of greatest elevation along the watershed, or that of the Icy Plateau, was situated between Lake Temiscamang and Lake Mistissinny; an that its trend was consequently northeast and southwest, thi being nearly that of the watershed between the lakes—a tren just right for a southeast movement of the ice.

Over the higher parts of the Green Mountains, *south* o Vermont, the amount of easting in the scratches diminishe southward, their direction being S. 40°–45° E. in northeaster Massachusetts; about S. 30° E. in southeastern Massachusetts and about S. 25° E. in Connecticut and in eastern New Yor adjoining. These directions correspond well with the positio assigned to the Icy Plateau. But as the Adirondacks lie between the two, it is not possible to say how far the courses ma have been dependent upon these New York mountains.

2. *Height of the Icy Plateau above the sea.*—The higher summits of the Green Mountains are, according to Guyot, betwee 3800 and 4430 feet in elevation, the latter being the height o Mt. Mansfield. Killington Peak, 60 miles south of Mt. Mansfield and east of Rutland, is 4221 feet high (Guyot). Th average height of the range, according to the same authority, i

about 3500 feet. The distance from Mt. Mansfield to southeastern Massachusetts is about 200 miles. The scratches of this mountain point southeastward toward the upper Merrimack valley; and those of this valley and of the adjoining region, down this valley in the direction of Boston Bay; and to this bay the distance from the summit of Mt. Mansfield is but 175 miles. Still, taking 200 miles as the length of the old glacier from Mt. Mansfield to the sea, and 3500 feet as the average height of the Green Mountains in Vermont, *the average rate of descent in the land is* 17½ *feet a mile*, and 20 feet a mile from the summits of the higher peaks. This was consequently the amount of slope that contributed toward the movement of the glacier over a large part of New England.

To have moved the same glacier from the northwestward *across the Green Mountains*, and to have abraded their highest summits and also scored surfaces on the White Mountains that are full 5200 feet above the sea, the propelling slope, or those of the Icy Plateau, must have certainly been higher than 5200 feet. We cannot assume that the rate of descent from the top of the Icy Plateau to the 5200 foot level on the White Mountains, a distance of about 400 miles, was as great as seventeen feet a mile; but we may reasonably infer it to have been at least *three* feet. This rate for 400 miles would make the height of the Plateau to average 6400 feet. The watershed is now about 1500 feet above the sea; accordingly, the average height of this region should have been at least 4900 feet greater than now.

A grade of *two feet* a mile would diminish this estimate 400 feet, making the required average height of the Icy Plateau 6000 feet.

The facts, therefore, demonstrate that this Canadian watershed was greatly higher—at least 4500 feet on an average—than at present. It is not supposed, or supposable, that the region was the course of a range of crested mountains that have since been washed away. No facts connected with glacial denudation, or that of subsequent time, favors such an extravagant assumption. All that the case demands is simply a bending upward of the surface over a wide area through a general continental movement of the crust having its greatest results to the north; and such we may believe it to have been. Similar oscillations of surface upward, and again downward, have taken place through all geological time, and they are still in progress; and geologists have detected them on some sea-shores where there is a standard water-level for comparison.

Moreover, the work of lifting continents and raising mountain chains went forward on a stupendous scale over Europe, Asia, and both Americas, through the whole era of the Tertiary; and this later upward movement in the higher latitudes of the continent followed on as the close of the long series, all the preceding elevations, as well as the last, being in preparation for the Glacial era.

Such an *upward* bending is no more improbable than the *downward* bending which the Iceberg theory of the drift assumes to have taken place; and even less so, *since* the latter must have been greater in *vertical change* of level, and also vastly wider in its limits from north to south; and moreover such an event would have been out of joint with the times, tending to ameliorate instead of giving arctic vigor to the climate. And further, as I pointed out many years since, (this Journal, II, vii, 379, 1849,) there is independent proof of a high-latitude elevation of the continent during the Glacial era, in the fact that the drift latitudes are also *fiord* latitudes,—the fiords occupying valleys of erosion by fresh water or ice, which could have been made only when the land was far above the present level.

A bulging of the crust in any region to a height of 4,500 or 5,000 feet above its present level would have carried up the part of the continent adjoining to a greater or less extent. If the above use of fiords is right, they may help us, wherever they occur, in arriving approximately at the amount of elevation in the Glacial era along sea borders. From the depth of those of Maine,—mostly 100 to 150 feet--we thus learn that the land along this coast was at least 150 feet higher than now, and probably 200 feet. Other facts lead us to believe, as stated by the writer in his paper on the Geology of the New Haven region, (Mem. Acad. Conn. ii, p. 45,) that southern New England was 100 to 150 feet above its present level. Hence, the coast line of New England would have been much extended outward by the change of level. Long Island Sound would have been reduced to a narrow channel, and Long Island joined to Connecticut, to which it geographically belongs. St. Lawrence Bay would have been greatly contracted, and the St. Lawrence River lengthened seaward over part of its present site. Lake Champlain would have poured its waters down the valley of the Hudson; and, as others have shown, Lake Michigan down the Mississippi valley.

The elevation of New England would have increased in amount from the southern shore northward, and from the southeastern northwestward, toward the Icy Plateau. Consequently the White Mountains, Mt. Mansfield and other Green Mountain peaks, and the Adirondacks of northern New York, would probably have stood at least 500 feet above their present level. If so, it is necessary, in order to have the slope of one averaging two or three feet in a mile, that as much at least should be added to the average height of the great northern Icy Plateau, which would make it 6,500 to 7,000 feet.

If the Icy Plateau, instead of being along the watershed, was situated to the north and northwest of it, somewhere in central or northern North America, the height must have been greater in proportion to the remoteness.

3. *The movement of the Glacier.*—The great glacier moved southeastward (the Icy Plateau trending northeastward) down the valley of the Ottawa and the slopes east of it, and marked its course deeply in the subjacent rocks. But on nearing the St. Lawrence, the lower part of its mass yielded to the impulse of gravity according with the slopes of this transverse valley, so that along this valley only *southwest* scratches were made, as facts show. Yet, the upper part of its mass continued on its first course, and, in northern New York and Vermont, and over southern Canada adjoining the latter State, the southeastward moving ice again touched bottom and resumed its work of abrasion. This is precisely parallel to what happened to the glacier, as I have shown, in its passage across the Connecticut River valley. In each case the valley determined the movement along its course of an under portion of the glacier, while the upper portion, spanning the valley, continued the grander movement initiated in the Icy Plateau, and favored by the general slope of New England. The great glacier, 6,000 to 8,000 feet in thickness, had no difficulty in keeping on its course according to the general slope of the land, and, at the same time, in following underneath the larger valleys or even many of the local slopes. It could not do otherwise. Icebergs in a continental sea, on the contrary, would have been puzzled to find all the criss-cross currents needed to help them along the valleys, up hill and down, and through all points of the compass.

4. *One cause of the cold of the Glacial era in North America.*—Increase in the extent and height of high-latitude lands may well stand as one cause of the cold of the American Glacial era. This rising of the land of northern Canada into a great plateau, at least as high as the summit of Mt. Washington, with the less elevation of wide regions north and south as a part of the great swell of the surface, and with the simultaneous elevation of other, perhaps higher, plateaus over the more northern and northwestern portions of the continent, and all a sequel to the majestic uplifts of the Tertiary, would have made a *Glacial* period for North America, whatever the position of the ecliptic, or whatever the eccentricity of the earth's orbit, though more readily of course if other circumstances favored. Having the most elevated land of eastern North America along the region pointed out, the courses of the winds and the distribution of moisture would have been different from the present. Canada being then on the *seaward* slope of the high land instead of, as now, on the landward slope, could not have had its comparatively dry climate with only an annual fall of 30 inches of moisture.

5. *Epochs of the Quaternary in North America.*—In view of the facts with regard to the elevated northern lands of the Glacial era here set forth—facts if Glaciers had anything to do with the Glacial phenomena—the epochs of the Quaternary, before deduced by the writer, come out in great boldness.

The movement of the GLACIAL era carried the northern lands upward, at least 5,000 feet above their present level in northern Canada, and probably as much or more over the higher latitudes to the west and north.

Then followed a slowly progressing subsidence—the great characteristic of the CHAMPLAIN era—which ultimately sank the same lands even to a greater extent than they had been raised, placing the valley of the St. Lawrence, about Montreal, over 500 feet below its present level, and probably 1,000 feet at least below its level in the Glacial era. With the commencement of this movement, or as it progressed, began the melting of the glacier; but the era continued, as proved by elevated beaches full of shells and other deposits, long after the melting ceased. During it, owing to the larger amount of subsidence to the north, north and south rivers had their slope greatly diminished, and in some places leveled out entirely for long distances; and owing to the vast depositions of drift, rivers, like Niagara, sometimes had their channels obstructed and were forced to begin new cuts, while other water-courses of the Glacial era were wholly cut off, as that from the Champlain Lake down the Hudson valley.

Afterward the return movement, that of the TERRACE era followed, placing the land finally at its present level, leading thus to a deepening of river channels, and thereby to the making of the river and lake terraces that cover the continent.

The fact of these grander movements which mark the three eras does not preclude the possibility of minor local oscillations of level during their progress.

ART. XLI.—*Variations in the Temperature of the Human Body;* by B. F. CRAIG, M.D. (Read before the Phil. Soc. of Washington).

IT is well understood that the temperature of the human body is kept approximately uniform under very various external conditions by a system of physiological compensations, and at the same time, it is not doubted that a certain amount of warming and of chilling does take place in spite of those compensations.

In disease, we have *occasionally* depressions of the temperature below the normal standard of 98.°4 Fah., and *frequently* considerable elevations above it—a rise of 2°, 4°, or even 6°

Fah., accompanying ordinary febrile disturbances. The peculiarity attending the rise of temperature in disease is that it is not much felt by the patient himself. In mild intermittent fever and in tubercular consumption, the heat of the body will often be found 1½° or 2° above the standard of health, while no sense of unusual heat, and sometimes no bodily discomfort of any kind, is felt by the sick man. Even in the more serious fevers, where the temperature goes up to 102°, 104°, or higher, there is not always a sense of increased heat proportioned to the disturbance of temperature: and moreover, the state of the temperature is governed mainly by the severity of the disease, and not by such external circumstances as the heat of the weather and the amount of clothing.

The great and long continued heat of the summer of 1870 gave me an opportunity, which seems unlikely to recur during the present summer, of investigating on myself to what extent the temperature of the healthy body was liable to rise under the influence of oppressively warm weather.

In the course of my experiments the highest temperature that I found was that of 99°·7 Fah. At this temperature I felt quite unpleasantly overheated, but not as much so as I would have been if instead of spending the morning indoors, I had been exposed to the rays of the sun in the open air. When the temperature of my body was below 99° I never felt uncomfortably hot. In fact, I satisfied myself by repeated trials, that a temperature of 99°·2 must be reached before the sensation of suffering from heat comes on.

During the hottest weather, I was able, by the prolonged use of the shower bath, to reduce my temperature to 97°·7. If, while at or about this temperature, I went into the street in the middle of a very hot day, the greatness of the heat was plainly felt as a sensation, but not as a cause of discomfort, as a man in cool weather might feel the glow of a furnace near which he was standing without being distressed by it. In fact, until my temperature had risen to 99°, I merely *perceived* how hot it was without being troubled by it.

It would thus appear that the discomfort we feel in hot weather is not from the impression of heat on the surface, but from the secondary effect of the heating up of the whole body; or rather, it is only when the heat of the whole body has risen nearly 1° Fah. that a check of the surface cooling begins to be unpleasant.

Very great elevations of temperature have been observed in sun stroke or heat apoplexy. That in all such cases the heat of the body rises above 100° Fah. before alarming symptoms manifest themselves, I think highly probable. Accurate thermometric examinations of mild cases of sun stroke and of persons supposed to be on the verge of apoplexy from excessive heat, may be pointed out as scientific desiderata.

In the Philos. Trans. for 1792 are to be found some curious experiments by Dr. James Currie, on the cooling of the human body by cold baths. He carried the reduction of temperature as low as 88° Fah., and this seemed, from the symptoms produced, to be as far as the heat of the body could be reduced with safety. It is to be hoped that some one may supplement these researches by experiments in the direction of the elevation of the animal temperature.

Art. XLII.—*Preliminary Catalogue of the bright lines in the Spectrum of the Chromosphere;* by C. A. Young, Ph.D., Professor of Astronomy in Dartmouth College.

The following list contains the bright lines which have been observed by the writer in the spectrum of the chromosphere within the past four weeks. It includes, however, only those which have been seen twice at least; a number observed on one occasion (Sept. 7th) still await verification.

The spectroscope employed is the same described in the Journal of the Franklin Institute for November, 1870; but certain important modifications have since been effected in the instrument. The telescope and collimator have each a focal length of nearly 10 inches, and an aperture of $\frac{7}{8}$ of an inch. Th prism-train consists of five prisms (with refracting angles o 55°) and two half-prisms. The light is sent twice through th whole series by means of a prism of total reflection at the en of the train, so that the dispersive power is that of twelv prisms. The instrument distinctly divides the strong iron lin at 1961 of Kirchhoff's scale, and separates B (not b) into it three components. Of course it easily shows everything tha appears on the spectrum maps of Kirchhoff and Angstrom The adjustment for "the position of minimum deviation" i automatic; i. e., the different portions of the spectrum ar brought to the center of the field of view by a movemen which at the same time also adjusts the prisms.

The telescope to which the spectroscope is attached is th new Equatoreal recently mounted in the observatory of th College by Alvan Clark & Sons.

It is a very perfect specimen of the admirable optical workmanship of this celebrated firm, and has an aperture of 9 inches, with a focal length of 12 feet.

In the table the first column contains simply the reference number. An asterisk denotes that the line affected by it has no we marked corresponding dark line in the ordinary solar spectrum

Preliminary Catalogue of Chromospheric Lines.

Kirchhoff.	Angstrom.	Rel. Frequency	Rel. Brightn's.	Chemical Element.	Previous Observer.
534·5	7060·?	60	3		
654·5	6677·?	8	4		L.
C	6561·8	100	100	H.	L. J.
719·0	6495·7	2	2	Ba.	
734·0	6454·5	2	3		
743·?	6481·	2	2		
768·?	6370·	2	2		
816·8	6260·3	1	1	Ti.	
820·0	6253·2	1	2	Fe.	
874·2	6140·5	6	8	Ba.	L.
D_1	5894·8	10	10	Na.	L.
D_2	5889·0	10	10	Na.	L.
1017·0	5871·	100	75		L. J.
1274·3	5534·0	6	8	Ba.	R. L.
1281·5	5526·0	1	1	Fe.	
1343·5	5454·5	1	2	Fe.	
1351·3	5445·9	1	2	Fe. Ti.	
1363·1	5433·0	1	1	Fe.	
1366·0	5430·0	2	3		
1372·0	5424·5	3	4	Ba.	L.
1378·5?	5418·0?	1	2	Ti.?	
1382·5	5412·	1	1		
1391·2	5403·0	2	2	Fe, Ti.	
1397·8	5396·2	1	2	Fe.	
1421·5	5370·4	1	2	Fe.	R.
1431·3	5360·6	2	2		R.?
1454·7	5332·0	2	2	Ti.	
1462·9	5327·7	1	3	Fe.	
1463·4	5327·2	1	3	Fe.	
1465·0?	5321·	2	2		
Cor'na line 1474·1	5315·9	75	15	Fe?	L.
1505·5	5283·	5	4		
1515·5	5275·0	7	5		L. R.
E_1	5269·5	1	3	Fe, Ca.	
E_2	5268·5	1	2	Fe.	
1528·0	5265·5	3	2	Fe, Co.	L.
1561·0	5239·0	1	1	Fe.	
1564·1	5236·2	1	1		
1567·7	5233·5	2	2	Mn.	R.
1569·7	5232·0	1	2	Fe.	
1577·3	5226·0	1	2	Fe.	
1580·5?	5224·5	1	1	Ti.	
1601·5	5207·3	3	3	Cr, Fe.?	
1604·4	5205·3	3	8	Cr.	
1606.5	5203·7	3	8	Cr, Fe.?	
1609·3	5201·6	1	2	Fe.	
1611·5	5199·5	1	1		
1615·6	5197·0	3	2		L. R.
b_1	5183·0	15	15	Mg.	L.
b_2	5172·0	15	15	Mg.	L.
b_3	5168·5	12	10	Ni.	L.
b_4	5166.5	10	10	Mg.	L.
1673 9	5153·2	1	1	Na.	

Ref. No.	Kirchhoff.	Angstrom.	Rel. Frequency	Rel. Brightn's.	Chemical Element.	Previous Observer.
54	1678·0	5150·1	1	2	Fe.	
55	1778·5	5077·8	1	1	Fe.	
56	1866·8	5017·5	2	3		R.
57	1870·3	5015·?	2	2		R.
58	1989·5	4933·4	8	5	Ba.	L.
59	2001·5	4928·2	5	3	Fe.	R. L.
60	2003·2	4921·3	1	1		
61	2007·1	4918·1	3	3		L.
62	2031·0	4899.3	6	4	Ba.	L.
63	2051·5	4882·5	2	2		L.
64	F.	4860·6	100	75	H.	J. L.
65	2358·5	4629·0	1	1	Ti.	
66	2419·3	4583·5	1	1		
67	2435·5	4571·4	1	1	Li.	
68	2444·0	4564·6	1	1		
69	2446·6	4563·1	1	2	Ti.	
70	2457·8	4555·0	1	1	Ti.	
71	2461·2	4553·3	3	3	Ba.	
72	2467·7	4548·7	1	3	Ti.	
73	2486·8	4535·2	1	1	Ti. Ca. ?	
74	2489·5	4533·2	1	1	Fe.	
75	2490·6	4531·7	1	1	Ti.	
76	2502·5	4524·2	2	2	Ba.	
77	2505·8	4522·1	1	2	Ti.	
78	2537·3	4500·4	1	3	Ti.	
79	2553·?	4491·0?	1	1	Mn. ?	
80	2555·?	4489·5?	1	1	Mn. ?	
81	2566·5	4480·4	1	2	Mg.	L.
82	2581·5?	4471·4	75	8	A band rather than a line.	
83	2585·5	4468·6	1	1	Ti.	
84	2625·0	4443·0	1	1	Ti.	
85	2670·0	4414·6	1	1	Fe, Mn.	
86	2686·7	4404·3	1	2	Fe.	
87	2705·0	4393·5	3	2	Ti.	
88	2719·?	4384·8	1	1	Ca. ?	
89	2721·2	4382·7	1	2	Fe.	
90	2734·?	4372·	1	1		
91	2737·?	4369·3?	1	1	Cr. ?	
92	2775·8	4352·0	1	1	Fe. Cr.	
93	2796·0	4340·0	100	50	H.	L. J.
94	G.	4307·0	1	2	Fe.Ti.Ca.	
95	2770·0	4300·0	1	1	Ti.	
96		4297·5	1	1	Ti, Ca.	
97		4289·0	1	2	Cr.	
98		4274·5	1	2	Cr.	
99		4260·0	1	1	Fe.	
100		4245·2	1	1	Fe.	
101		4226·5	1	1	Ca.	
102		4215·5	1	2	Fe. Ca.	
103	*h.*	4101·2	100	20	H.	R. L.

The second column gives the position of the line upon th scale of Kirchhoff's map—determined by direct compariso with the map at the time of observation. In some cases an interrogation mark is appended, which signifies not that the *existence* of the line is doubtful, but only that its precise place could not be determined, either because it fell in a shading of fin lines, or because it could not be decided in the case of som close double lines which of the two components was the bright one; or finally because there were no well marked dark lines near enough to furnish the basis of reference for a perfectl accurate determination.

The third column gives the position of the line upon Angstrom's normal atlas of the solar spectrum. In this column a occasional interrogation mark denotes that there is some doub as to the precise point of Angstrom's scale corresponding t Kirchhoff's. There is considerable difference between the tw maps, owing to the omission of many faint lines by Angstrom and the want of the fine gradations of shading observed b Kirchhoff, which renders the coördination of the two scale sometimes difficult, and makes the atlas of Kirchhoff far superior to the other for use in the observatory.

The numbers in the fourth column are intended to denot the percentage of frequency with which the correspondin lines are visible in my instrument. They are to be regarded a only roughly approximative; it would of course require a muc longer period of observation to furnish results of this kin worthy of much confidence.

In the fifth column the numbers denote the relative brillian of the lines on a scale where 100 is the brightest and 1 th faintest. These numbers also, like those in the preceding column, are entitled to very little weight.

The sixth column contains the symbols of the chemical substances to which, according to the maps above referred to, th lines owe their origin.

There are no disagreements between the two authorities; i a majority of cases, however, Angstrom alone indicates the element, and there are several instances where the lines of mo than one substance coincide with each other and with a line the solar spectrum so closely as to make it impossible to decid between them.

In the seventh and last column the letters J., L. and R. denote that to my knowledge the line indicated has been observed and its place published by Janssen, Lockyer or Ray It is altogether probable that a large portion of the other lin contained in the catalogue have before this been seen and located by one or the other of these keen and active observer but if so I have as yet seen no account of such determinations.

I would call especial attention to the lines numbered and 82 in the catalogue: they are very persistently present, hough faint, and can be distinctly seen in the spectroscope to elong to the chromosphere as such, not being due, like most of he other lines, to the exceptional elevation of matter to heights here it does not properly belong. It would seem very proba- le that both these lines are due to the same substance which auses the D^3 line.

I do not know that the presence of *Titanium vapor* in the rominences and chromosphere has before been ascertained. It omes out very clearly from the catalogue, as no less than 20 of he whole 103 lines are due to this metal.

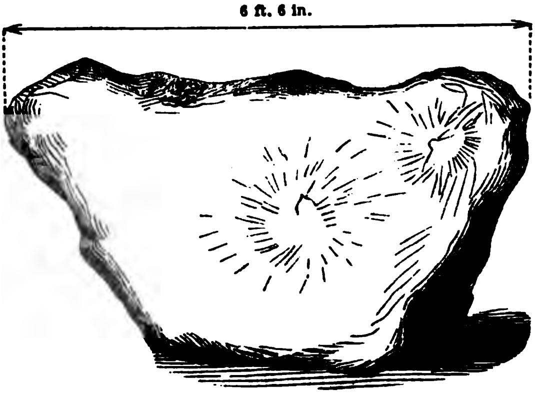
Hanover, N. H., Sept. 13, 1871.

RT. XLIII.—*The precise Geographical position of the large masses of meteoric iron in North Mexico, with the description of a new mass—The San-Gregorio Meteorite;* by J. LAWRENCE SMITH, Louisville, Ky.

SOME of the remarkable masses of meteoric iron in Northern Mexico have been known to travelers for a number of years; ut no very precise information concerning them had been iven until the year 1854, when the first mass, brought from hat locality, was placed at my disposal by Lieut. Gouch of the U. S. Army, and was described in a memoir on meteorites ublished in the American Journal of Science, April, 1854; it s now in the Smithsonian Museum, and weighs 252 lbs.

On the return of Mr. Bartlett, of the Boundary Commission, learned of two other masses in that region, and Lieut. John G. Parke, of the U. S. Army, placed a fragment of one of them n my possession; the fragment of the other mass was lost. figured and described both of those meteorites in the memoir ust alluded to; the first, which I called the *Tucson Meteorite*, is ow in the Smithsonian Institute, and weighs, I believe, several housand pounds; the second one I called the *Chihuahua iron*, nd is still at the *Hacienda de Conception*, where it was first ound. Still later in the year 1868, Dr. H. B. Butcher placed nder my examination eight masses of meteoric iron that had been brought to the United States from the same region of Mexico; these I examined, and published a full account of n the American Journal of Science. These masses are now in Philadelphia, still owned by Dr. Butcher, and vary in weight from about 300 lbs. to 800 lbs. Dr. Butcher having returned to Mexico, I requested him to get all possible information in regard to the geographical position of these bodies; this he has succeeded in accomplishing. At the same time he has a fragment of another mass, still larger than any yet known, which will be called the *San-Gregorio Meteoric Iron.* Its description is as follows:

The San-Gregorio Meteorite.—This immense mass of meteoric iron is situated on the western border of the Mexican Desert, a map of which is given on the next page. Some idea of its form may be had in the accompanying sketch.



It measures 6 feet 6 inches in its greatest length, is 5 feet 6 inches high, and 4 feet thick at its base; on one part of its surface, 1821 is cut with a chisel, and above this date is the following inscription: "*Solo dios con un poder este fierro destruerá, por que en el mondo no habra quien lo puede deschacer.*"

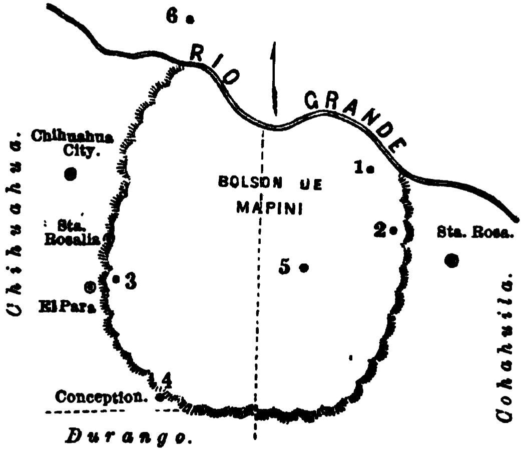
It lies within the enclosure of a hacienda, having been hauled to the ranch many years ago by the Spaniards who thought that it could be made use of as iron for farming utensils. It is said to have fallen quite near its present site, and from its huge bulk and weight, which is calculated to be about five tons, it could not have been transported very far. Nothing more is known of its history. Small specimens were detached by Dr. Butcher, one of which I have examined. I find it to be of the softer meteoric irons, with a specific gravity of 7·84. The fragment I possess is too small for the study of the true character of its Widmannstätian figures.

On analysis, it furnished the following composition:

Iron,	95·01
Nickel,	4·22
Cobalt,	·51
Copper,	minute trace
Phosphorus,	0·08

This *San-Gregorio* iron makes the fifth that has come under my observation and examination from this famous Mexican locality, the geography of which I will now describe, referring to the accompanying diagram for details.

The Bolson de Mapini or Mexican Desert occupies the western portion of the province of Cohahuila, and the eastern portion of the province of Chihuahua. It is 400 miles from east to west, and 500 miles from north to south, bounded on the north by the river Rio Grande. Some of the villages and haciendas are specified in the diagram, and the numbers 1, 2, 3, &c., are the localities of the different meteoric masses discovered.



No. 1. The locality of the *Cohahuila* meteorite described by me in this Journal, April, 1854; it is now in the Smithsonian Institution.

No. 2. The locality of the *Cohahuila* meteorite of 1868, described by me in this Journal, April, 1870; it is now in the possession of Dr. Butcher.

No. 3. The locality of the *San-Gregorio* meteorite just described; it is still in the place where it was first observed.

No. 4. The locality of the mass described and figured in my memoir on meteorites (this Journal, April, 1854), and called the *Chihuahua Meteorite;* it is still in place at the *Hacienda de Conception*, 10 miles from Zapata, its greatest height being forty-six inches, breadth thirty-seven, and in the thickest part eight feet three inches in circumference. Signor Urquida calculated its weight to be about four thousand pounds.

No. 5. The locality of a huge meteorite lately discovered, of which no specimen has yet been detached, and is said to be larger than any one yet found in that locality.

No. 6. The locality of the large mass described and figured by me in 1854 as the *Tucson iron*, and now in the Smithsonian Institution at Washington, having a large hole in the center, and sometimes called the *Signet Meteorite*, also the *Ainsa Meteorite*. I do not know its exact weight, but suppose that it must weigh two or three thousand pounds.

The question naturally arises, what can be the cause of the number of meteoric masses in the circumscribed region, and whether each one represents a separate fall? My study of them leads me to the belief that they are the products of two falls. First of all, No. 6, the Signet or Ainsa meteorite, has peculiar physical and chemical characters that separate it entirely from the others. Nos. 1, 2 and 3 I have examined chemically, and find them very closely allied in composition, also in physical properties, as the softness of the iron and freedom from rusty crusts over the exterior; in fact the pieces I have examined were more or less bright on the exterior surface. The Widmannstätien figures I have not had an opportunity to compare, since, with the exception of No. 1, I have had only small pieces that were detached from the surface by a cold chisel, which are unfit for the study of these figures. Thus far in my investigation, there appears strong reasons for supposing that at some epoch, probably far remote, the meteoric masses 1, 2, 3, 4 and 5 were the products of the fall of one meteoric mass, moving from the northeast to the southwest, the smaller masses falling first at 1 and 2, and the larger masses farther on. The distances of these bodies from each other are, from Nos. 1 to 2 about 85 miles, from 2 to 5 about 135 miles, from 5 to 3 about 165 miles, from 3 to 4 about 90 miles. Of course these is no great stress laid upon these deductions, but it would not be surprising if further investigation should sustain this view.

Since my first publication on these meteorites, Burckhardt, of Bonn, has made some observations upon them, but his publications are not within my reach at the present time.

Art. XLIV.—*On the Iridium compounds analagous to the Ethylen and Protochloride of Platinum Salts*;* by Prof. Samuel P. Sadtler, Ph.D., Pennsylvania College, Gettysburg, Pa.

Among the compounds which we are accustomed to call *organo-metallic*, those of $PtCl_4$ and $PtCl_2$ play perhaps the most important part. We can separate them, however, into the two great classes—those where the $PtCl_4$ and $PtCl_2$ enter by substitution into compound ammonia-atoms, and thus form bases more or less complex, but having still a certain connection; and those where the $PtCl_4$ and $PtCl_2$ take up organic radicals of different degrees of valence to form saturated compounds.

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* Extract from an Inaugural dissertation at the Univ. of Göttingen, April, 1871.

The range of this last class, as can be seen, is very wide; one of the most prominent of these compounds, however, and one which exercised for some time a very considerable influence upon the theoretical views held at that time, is the compound of $PtCl_2$, known as Zeise's salt, and discovered and investigated by him in 1830.

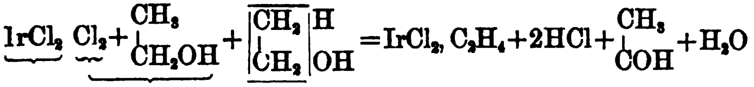
It is not necessary to recount here the controversy which took place between Zeise and Liebig on the subject. Suffice it to say that, by subsequent investigations of Griess and Martius and of Birnbaum, its formula is definitely settled as $PtCl_4$, C_2H_4+KCl.

The investigation I now undertook was to see if a similar base of iridium could be prepared. Various considerations, stated at length in my original paper, led me to believe that iridium might not combine exactly as platinum did, in the formation of these salts.

After obtaining the double chloride of iridium and ammonium in the usual way, by decomposing the osmiridium, I made some tests as to the manner of formation of the salt. An attempt to form it by taking the double chloride of iridium and ammonium in solution, and, passing a stream of chlorine through to break up the chloride of ammonium, to then conduct ethylen gas into it, was unsuccessful. The method which succeeded most perfectly was to act upon iridium chloride. This was obtained by igniting the double chloride of iridium and ammonium, thus obtaining iridium oxide and metallic iridium, which was then heated with aqua regia in sealed tubes of bohemian glass to 180° or 200°C. This solution of $IrCl_4$, I then treated with absolute alcohol. On adding KCl, and allowing it to crystallize out, I got the greenish-brown crystals of the iridium-ethylen base. On subjecting them to an organic combustion, I obtained as products carbonic acid and water. They burned with a luminous flame, and answered, in short, all the tests applied to Zeise's platinum salt.

Another experiment, to see if ethylen gas would act directly upon the $IrCl_4$, reducing it and uniting at the same time, was unsuccessful.

It will thus be seen, that the only method of preparing the iridium-base is by the reducing action of alcohol on iridium chloride, according to the reaction:—



$$\underbrace{\mathrm{IrCl_2}}\;\underbrace{\underset{\sim}{\mathrm{Cl_2}}+\underbrace{\begin{array}{c}\mathrm{CH_3}\\|\\\mathrm{CH_2OH}\end{array}}+}\left|\overline{\underline{\begin{array}{c}\mathrm{CH_2}\\|\\\mathrm{CH_2}\end{array}}}\right|\begin{array}{l}\mathrm{H}\\\mathrm{OH}\end{array}=\mathrm{IrCl_2,\,C_2H_4}+2\mathrm{HCl}+\begin{array}{c}\mathrm{CH_3}\\|\\\mathrm{COH}\end{array}+\mathrm{H_2O}$$

the products of which are iridium-ethylen-protochloride, hydrochloric acid, aldehyde and water.

The purifying of the necessary iridium was found to be a very long and tedious operation, the last traces of platinum sticking very pertinaciously to the iridium salt. The processes in use also leave much to be desired in the way of completeness and expedition.

The method selected for separation was the method of Birnbaum, grounded upon the distinct and separate crystallization of the double cyanides of iridium and barium and platinum and barium. To convert the double chlorides of iridium and ammonium, and platinum and ammonium into the double cyanides of iridium and potassium, and platinum and potassium, after trying Wöhler's and Muckle's method and obtaining unsatisfactory results, I had recourse to Martius' method. This consists in mixing the dry impure chloride of iridium and ammonium with powdered cyanide of potassium, and fusing and then taking up with water the fused mass. After working some time with this method, with rather poor results, owing to the high heat required to bring the mass to fusion and the invariable decomposition of the newly formed double cyanides, resulting from the application of such a heat, I modified the method in several particulars. I found, on trying, that the black iridium oxide went very readily into solution in the fused cyanide of potassium. Taking, therefore, the double chloride of iridium and ammonium and igniting it to transform it into the iridium oxide, I proceeded after the following manner. Covering the bottom of the crucible with a bed of powdered KCy, I then added a mixture of KCy and iridium oxide, and exposed it to the flame of the blast-lamp. The fusing cyanide takes up quite readily the metallic oxide, and is soon in calm fusion. A reduction still takes place, but by no means to the extent experienced before. This is occasioned by the strong heat which has to be applied to get the mass into full fusion. Another modification which I then made has some advantages over this just described. It is to bring a few pieces of KCy to full fusion, and then keeping it so, to add a previously prepared mixture of the iridium oxide and finely pulverized cyanide of potassium to it, in small quantities at a time. The advantage here is, that, when the KCy has once been brought to fusion, it can be kept there with a comparatively small flame, and the reduction of the double cyanides does not occur so readily. It is true, that adding the iridium so slowly, the compound is kept in the fused state longer. My experience, however, leads me to prefer this latter plan, and I generally used it as giving the largest yield. Birnbaum's method proper is now used. The solution of the double cyanides, filtered off from any unattacked iridium oxide, contains a tolerably large excess of free KCy. This is destroyed by adding dilute HCl. When neutral, a concentrated solution of copper vitriol is added. The violet-colored precipitate of mixed double cyanides of iridium and platinum with copper is washed by decantation with boiling water. While suspended therein, a strong solution of caustic baryta is added. The copper is thrown down as brown oxide of copper, and the double cyanides of iridium and platinum with barium are formed, which remain in solution. When the fluid reacts distinctly alkaline, after a minute or so boiling, it is filtered off, and then CO_2 is passed through, until a neutral reaction is obtained. Filter off the precipitate of $BaCO_3$, and then concentrate for crystallization. The yellow platinum salt crystallizes out first in small crystals, with a play of colors from yellow to blue, being similar in their dichroic effects to most of the other double cyanides of platinum. The iridium salt crystallizes then in larger colorless prisms, which can be easily separated mechanically from the platinum crystals. The iridium crystals I ignited in a porcelain crucible, and having thus completely broken up the compound, drew out the baryta with boiling water. The iridium, after being well washed and ignited to completely oxidize it, was heated as before with aqua regia in a sealed tube to 200°C. The $IrCl_4$ solution obtained was again treated with absolute alcohol, and, on addition of KCl and NH_4Cl, the crystallized salts were obtained.

However the compounds which were now formed were, contrary to my expectations, not the ethylen salts pure and alone, but there was a simultaneous formation of what appear to be several distinct compounds. Although in one preparation of ammonium salt analyzed, the ethylen-protochloride-salt was isolated tolerably pure, yet, in the majority of the analyses, I had to do with a mixture difficult to separate even under the lens. The readiness with which these compounds decompose when subjected to recrystallization, even although one observes the precaution of keeping the solution distinctly acid, prevents any successful purifying that way. The preparation, therefore, had to be prepared for analysis by drying between bibulous paper, and then over H_2SO_4 or at 100°, according as I wished to determine the percentage of water or not. A certain amount of HCl from the acid solutions therefore, adhering to the crystals, made the Cl determinations as a rule high. Still the results approximate sufficiently, these circumstances being taken into consideration, to the formulas given, to show that several distinct compounds are here formed. My first crystallization consisted of brownish-red octahedra, which when analyzed gave in three Cl determinations 42·18 pr. ct., 42·07 pr. ct. and 42·09 pr. ct. Cl, showing them to be simple $IrCl_4(KCl)_2$, of which the percentage of Cl is 42·08 pr. ct.

I next got a crystallization of fine, sharply-formed monoclinic crystals of a reddish-brown color, which I think the analyses, although not perfectly conclusive, still go to show to be a new compound. Several different crystallizations of it were analysed. It could not always be entirely separated from the slight crust of decomposed KCl which separated out along with and among the crystals.

Preparation No 1. Large well-formed crystals, with but very little foreign matter adhering to the sides.

·1567 grms. dried over H_2SO_4 lost by heating to 100° ·0170 grms. = 10·85 pr. ct.:
gave ·0525 grms. metallic iridium = 33·50 pr. ct.:
gave also ·2275 grms. AgCl = ·0563 grms. Cl = 35·92 pr. ct.
·1610 grms. dried over H_2SO_4 lost by heating to 100° ·0172 grms. = 10·68 pr. ct.:
gave — Ir. determination accidentally spoiled:
gave also ·2320 grms. AgCl = ·0574 grms. Cl = 35·65 pr. ct.

This we see at once cannot be any chloride of iridium and potassium. Its luminous flame, too, when burned, shows the same. Nor do the percentages agree with the simple potassic-ethylen iridium protochloride $IrCl_2C_2H_4KCl+2H_2O$ where the Ir. = 48·45 pr. ct. and Cl = 26·19 pr. ct.

If we reckon out the ratio of iridium to chlorine, we find it as 1 : 6, showing it to be an iridium-chloride compound. The large pr. ct. of loss on heating, the small Ir. and Cl pr. cts., when compared with double iridium and potassic chloride, and the luminous flame when burned, all go to show that an organic constituent must make the additional pr. ct. If we suppose now ethylen to enter here into the union with iridium chloride, hanging itself on, we can expect from the consideration of analogous compounds that 2 atoms of the bivalent radical C_2H_4 would join the atom $PtCl_4$.

We would have on this supposition the formula $IrCl_4(C_2H_4)_2(KCl)_2 + \chi H_2O$. Now this formula with 3 atoms H_2O gives Ir. = 32·93 pr. ct., Cl = 35·61 pr. ct., and with 2 atoms H_2O, Ir. = 33·95 pr. ct., Cl = 36.71 pr. ct.; anhydrous it gives Ir. = 36·20 pr. ct. and Cl = 39·14 pr. ct.

The large pr. ct. of loss at 100° is not accounted for by $3H_2O$, which give only 9·03 pr. ct.; but it is possible that in a compound where the organic constituent is so loosely connected with the rest, as must be the case here, a partial decomposition of the salt enters at 100° already.

In another preparation, also well crystallized, ·1822 grms. dried at 100°:
gave ·0678 grms. metallic iridium = 37·21 pr. ct.;
gave also ·3063 grms. AgCl = ·0758 grms. Cl = 41·59 pr. ct.

In another preparation, indistinctly crystallized, ·0502 grms. dried at 100°:
gave ·0172 grms. metallic iridium = 34·26 pr. ct.
(Probably low from HCl mechanically admixed.)

In another preparation, also indistinctly crystallized, ·3207 grms. dried at 100°:

gave ·2125 grms. AgCl = ·1268 grms. Cl = 39·53 pr. ct.

It will thus be seen the determinations, all things considered, agree close enough with the theoretical pr. cts. of the formula to make it very probable. The want of enough sufficiently-well crystallized material prevented me from making an organic combustion which might settle it definitely.

Several individual crystals of the first crystallization were very sharply and clearly formed, and I subjected them to examination under the microscope with a power of about 50 diameters. The faces were clearly to be made out. They belong to the monoclinic system, and their prevailing habitus in crystallization is a combination of the two lateral pinacoids with positive and negative pyramids accompanied by one macrodome on the ends. The faces observed in an examination of five distinct crystals were (according to Naumann) $\infty P \infty$. $\infty P \grave{\infty}$ $+P$. $-P$. $+\frac{1}{2}P$. $-\frac{1}{2}P$. $+P\infty$. $-P\infty$.

In considering the compounds of the iridium-base with NH_4Cl, we find again a mixture of crystallized salts.

Preparation No. 1 consisted of sharply crystallized needles that looked almost black, and only by transmitted light showed a brownish-green color. They were also monoclinic.

On analysis they prove, I think, to be the sought-for ethylen-iridium compound.

·0713 grms. dried over H_2SO_4 lost on heating to 100° ·0029 = 4·07 pr. ct.:

gave ·0850 grms. AgCl = ·0210 grms. Cl = 29·49 pr. ct. or 30·74 pr. ct. of salt dried at 100°.

The iridium determination was made with magnesium, and was inaccurate as before.

The formula $IrCl_2C_2H_4NH_4Cl + H_2O$ = 367·5 demands Cl = 28·98 pr. ct., H_2O = 4·89, or anhydrous 30·47 pr. ct. Cl.

Preparation No 2 was of much smaller needles and of lighter color.

Analyses show it to be of very similar composition to the potassium salt described above.

·1207 grms. dried at 100° C.:

gave ·0495 grms. metallic Ir. = 41·97 pr. ct.:

gave also ·2068 grms. AgCl = ·0512 grms. Cl = 43·37 pr. ct.

$IrCl_4(C_2H_4)_2(NH_4Cl)_2$ = ·502 gives Ir. = 39·25 pr. ct. and Cl = 42·43 pr. ct., and supposing it to lose some of the C_2H_4 at 100°, as stated above, $IrCl_4(C_2H_4)(NH_4Cl)_2$ would give Ir. = 41·50 pr. ct. and Cl = 44·94 pr. ct.

The other two preparations of the ammonium salt analysed appeared under the lens to be mixtures of the iridium protochloride-ethylen salt and the iridium chloride-ethylen salt given above.

The results were—

·1322 grms. dried at 100°:
gave ·0609 grms. metallic iridium = 46·07 pr. ct.
·1715 grms. dried at 100°:
gave ·0784 grms. metallic iridium = 46·95 pr. ct.
$IrCl_2\ (C_2H_4)(NH_4Cl) + H_2O$ gives Ir. = 53·61 pr. ct.
$IrCl_4\ (Cl_2H_4)_2\ (NH_4Cl)_2$ gives Ir. = 39·25 pr. ct.

The existence of the base $IrCl_4\ (C_2H_4)_2$,

I hope to settle definitely by renewed analyses of larger quantities.

While engaged with the preparation of the ethylen and iridium compound, the thought of the possibility of acetylen (C_2H_2) uniting with $PtCl_2$ or $IrCl_2$ led me to make some experiments in that direction. After a number of endeavors to form a platinum salt and analyses of the products (a detailed account of which is given in the original paper), I obtained negative results only. The existence of such a salt is highly improbable.

ART. XLV.—*Directions for Constructing Lightning-Rods.* From Essays on Meteorology; by Prof. JOSEPH HENRY.*

1st. The rod should consist of round iron, of not less than three-fourths of an inch in diameter. A larger size is preferable to a smaller one. (Ordinary gas pipe may be employed). Iron is preferred, because it can be readily procured, is cheap, a sufficiently good conductor, and, when of the size mentioned, cannot be melted by a discharge from the clouds. Other forms of rod, such as flat or twisted, will conduct the lightning, and in most cases answer sufficiently well. They tend, however, to give off lateral sparks from the sharp edges at the moment of the passage of the electricity through them, which might, in some cases, set fire to very combustible materials.

2d. It should be, through its whole length, in perfect metallic continuity; as many pieces should be joined together by welding as practicable, and, when other joinings are unavoidable, they should be made by screwing the parts firmly together by a coupling ferule, care being taken to make the upper connection of the latter with the rod water-tight by cement, solder, or paint.

3d. To secure it from rust, the rod should be covered with a coating of black paint.

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* Smithsonian Miscellaneous Collections.

4th. It should be terminated above with a single point, the cone of which should not be too acute, and to preserve it from the weather, as well as to prevent its being melted, should be encased with platinum, formed by soldering a plate of this metal, not less than a twentieth of an inch in thickness, into the form of a hollow cone. Points of this kind can be purchased of almost any mathematical instrument maker. Usually the cone of platinum, for convenience, is first attached to a brass socket, which is secured on the top of the rod, and to this plan there is no objection. The platinum casing, however, is frequently made so thin, and the cone so slender, in order to save metal, that the point is melted by a powerful discharge.

5th. The shorter and more direct the rod is in its course to the earth the better. Acute angles, made by bending the rod, and projecting points along its course, should be avoided.

6th. It should be fastened to the house by iron eyes, and may be insulated by cylinders of glass. We do not think the latter, however, of much importance, since they soon become wet by water, and, in case of a heavy discharge, are burst asunder.

7th. The rod should be connected with the earth in the most perfect manner possible; and in cities nothing is better for this purpose than to unite it in good metallic contact with the gas-mains or large water-pipes in the streets; and, indeed, such a connection is absolutely necessary, if gas or water-pipes are within the house. Electricity, by what is called induction, acts at a distance on the perpendicular gas-pipes within a house, rendering them so highly negative, the cloud being positive, as to attract the electricity from a lightning-rod imperfectly connected with the earth, or even from the air through the roof. Damage to buildings on this account is of constant occurrence. The above connection can be made by soldering to the end of the rod a strip of copper, which, after being wrapped several times around the pipe, is permanently attached to it. Where a connection with the ground cannot be formed in the way mentioned, the rod should terminate, if possible, in a well, always containing water; and, where this arrangement is not practicable, it should terminate in a plate of iron or some other metal buried in the moist ground. It should, before it descends to the earth, be bent, so as to pass off nearly at right angles to the side of the house, and be buried in a trench, surrounded with powdered charcoal.

8th. The rod should be placed, in preference, on the west side of the house, in this latitude, and especially on the chimney from which a current of heated air ascends during the summer season.

9th. In case of a small house, a single rod may suffice, provided its point be sufficiently high above the roof; the rule being observed, that its elevation should be at least half of the distance to which its protection is expected to extend. It is safer, however, particularly in modern houses, in which a large amount of iron enters into the construction, to make the distance between two rods less than this rule would indicate, rather than more. Indeed, we see no objection to an indefinite multiplication of rods to a house, provided they are all properly connected with the ground and with each other. A building entirely inclosed, as it were, in a case of iron rods so connected with the earth, would be safe from the direct action of the lightning.

10th. When a house is covered by a metallic roof, the latter should be united, in good metallic connection, with the lightning rods; and in this case the perpendicular pipes conveying the water from the gutters at the eaves may be made to act the part of rods, by soldering strips of copper to the metal roof and pipes above, and connecting them with the earth by plates of metal united by similar strips of copper to their lower ends: or, better, with the gas or water-pipes of the city. In this case, however, the chimneys would be unprotected, and copper lightning-rods, soldered to the roof and rising a few feet above the chimneys, would suffice to receive the discharge. We say soldered to the roof, because, if the contact was not very perfect, a greater intensity of action would take place at this point, and the metal might be burnt through by the discharge, particularly if it were thin.

11th. As a general rule, large masses of metal within the building, particularly those which have perpendicular elevation, ought to be connected with the rod. The main portion of the great building erected for the World's Exhibition at Paris was entirely surrounded by a rod of iron, from which rose at intervals a series of lightning-conductors, the whole system being connected with the earth by means of four wells, one at each corner of the edifice.

The foregoing rules may serve as general guides for the erection of lightning-rods on ordinary buildings, but for the protection of a large complex structure, consisting of several parts, a special survey should be made, and the best form of protection devised which the peculiar circumstances of the case will admit.

ART. XLVI.—*The Paragenesis and Derivation of Copper and its associates on Lake Superior;* by RAPHAEL PUMPELLY.

[Continued from pages 188 and 258.]

Chalcocite, Bornite, Whitneyite, Domeykite.—Two fissure-veins are known in the neighborhood of Portage Lake which carry these ores. They have been examined only very superficially; but it is a remarkable fact that the amygdaloids traversed by these veins contain only native copper. One of the fissure-veins, bearing both sulphides and arsenides of copper, enters the Grand Portage cupriferous amygdaloid bed, which bears only native copper, and remains in it with a changed direction for a short distance. The gangue of these veins is quartz, calcite and a carbonate of lime containing some iron and magnesia—ankerite?

The only other instance I have observed of the occurrence of copper in combination with sulphur, is in the fissure-vein of the Mendota property, near Lac la Belle. This vein appears to traverse the entire trappean series from Agate Harbor on the north to Lac la Belle.

Wherever this vein has been opened or uncovered, along the greater part of its course, north of the Mendota property, only *native* copper has been found; but when it enters a bed of conglomerate on the north flank of Mt. Bohemia, the little copper it contains is combined with sulphur in a very pure chalcocite. Where the vein passed from the conglomerate into the underlying amygdaloid, a fine deposit of chalcocite with calcite was found to have been formed, for a short distance, on both sides of the vein, between the two beds.

Still farther south the vein enters a mass of syenite, consisting of a pink triclinic feldspar, some hornblende and much chlorite, as an alteration-product of hornblende, and containing frequent impregnations of chalcopyrite, bornite, and, more rarely, chalcocite. In this syenite the vein and its many feeders carry bornite and considerable quantities of a bluish sulphuret of copper, in sheets ⅓ to ¾ inch thick, which has a very crystalline structure and exhibits octahedral cleavage.*

Near the contact between the syenite and trap the latter rock is impregnated with magnetite, specular-iron, chalcopyrite and bornite. Excepting the syenite, wherever copper is found in the traps and amygdaloids on the Mendota property, it is in the metallic state. The occurrence of the sulphides and arsenides of copper in this isolated manner and in fissure-veins traversing rocks more or less impregnated with metallic copper, seems t show a diversity of origin for the sulphur and arsenic on the on hand, and the copper on the other. It does not seem unreasonable to suppose the copper to have entered the vein-fissure from the adjoining rocks in solution, as carbonate, sulphate or silicate, and to have been then precipitated by sulphureted hydrogen and arseniureted hydrogen respectively. Or the copper may have been deposited in these as in the other veins, in th metallic state, and have been subsequently changed by the sam gases. In the case of the pseudomorphous chalcocite, wher the Mendota vein traverses syenite, cuprite must have bee formed by the oxydation of chalcocite or of native copper, and the oxide must have been subsequently decomposed by sulphureted hydrogen.

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* Prof. Cooke, after a casual examination of this mineral, suggests that it is probably a pseudomorph of chalcocite after cuprite.

The Huronian formation, which probably underlies all thi region, contains in its upper members large amounts of carbonaceous matter in the form of graphite; the gases may have originated in a reduction of sulphates and arseniates by the carbo of these beds.

Among the pebbles in the Calumet conglomerate there is variety of quartz porphyry, with a brown, compact, almos jaspery matrix, which only glazes slightly before the blowpipe. In this paste, there are numerous grains of dark quart $\frac{1}{20}$–$\frac{1}{4}$ inch in diameter, and often more frequent crystals o flesh-red feldspar, apparently orthoclase,—$\frac{1}{16}$ to $\frac{7}{16}$ inches i length.

It not rarely happens, that in these flesh-red crystals ther appear dirty green portions exhibiting the twine striation of triclinic variety. The feldspar is hard and brilliant, but i nevertheless no longer intact; under the glass the crystals appear cavernous, 10 per cent or more of the substance bein gone. This is the character of this porphyry in the freshes pebbles.

I have before me a pebble 4 inches in diameter, broke through the middle. It was the same variety of porphyry have just described—the same brown matrix, with the sam grains of quartz, and the same large crystals of orthoclase often enclosing crystals of triclinic feldspar. But this pebbl carries on its face the history of an extreme change. In th interior, where it is freshest, the matrix, still of the same brow color, has become so soft as to be easily scratched with th point of a needle. The quartz grains are highly fissured, an the surfaces of the fissures are covered with a soft light-gree magnesian mineral. The feldspar, although it still resists th point of the steel needle, has generally lost its glance, and ha an almost earthy fracture; it is lighter colored, and tends t spotted dirty-red and white. In places, specks of chlorite ar visible in the holes in the altered feldspar, and the cleavage planes often glisten with flakes of copper. As we go further from the middle of the specimen toward the original surface of the pebble, the matrix becomes much softer, though still with brown color and brown streak, and then changes to a soft green chloritic mineral, which whitens before the blow-pipe, and fuses on the edges to a grey glass. A little further from the center there is no longer a trace of the porphyry matrix: it is altered wholly to chlorite. The feldspar crystals are somewhat more altered here than they are in the middle of the pebble, but the quartz grains seem to have been in part replaced by chlorite. The change to chlorite is accompanied throughout by the presence of a large amount of copper. While in the interior of the pebble, the flakes of copper are confined to the cleavage planes of the feldspar, and the porphyry matrix exhibits scarcely a trace of the metal, the chlorite which has replaced the matrix contains in different parts of the specimen from 10 to 60 per cent, by weight, of copper.

In another pebble of the same porphyry, not only is the original matrix gone, but the usurping chlorite has been almost, if not wholly, replaced by copper; and we have as the remarkable result a quartz-porphyry, whose crystals of feldspar and grains of quartz lie in a matrix of metallic copper. There is still a very small amount of chlorite present, but it seems to have come from the change of the feldspar crystals and quartz grains.

In other pebbles of the same quartz-porphyry, containing, perhaps, less quartz, the alteration seems to have taken a somewhat different direction, or at least, the result before us is different. In the interior of the pebble, the matrix is of a darker and dirtier brown than in the previous cases, which may be due to the presence of manganese in the alteration product Going from the middle, the brown color changes rather abruptly to a dirty greenish-gray; the material also becomes softer, but it is earthy, with an earthy odor, and gritty to the touch. The change seems here to be in the direction of kaolinization.

The entire pebble is permeated with minute shining threads and plates of carbonate of lime. The lighter-colored portion contains considerable copper, while nearer the surface of the pebble it is largely replaced by that metal. Pebbles showing the various alterations described above are by no means rare. Many of them, from 1 inch to 1 foot in diameter, are found every day.

III. *Conclusions.*

We may be permitted to draw a few conclusions from the facts brought out in the observations thrown together in the foregoing pages.

I. The *Chlorite* of the melaphyr, and consequently the distinctive character of that rock, is due to the alteration of hornblende or pyroxene. This seems to have been the first step toward the production of melaphyr proper. *Laumontite*, which we find alike in the beds containing the least and in those containing the most chlorite, and occurring both diffused and concentrated in seams, appears to have been formed either contemporaneously with the chlorite, or as the next step in the process.

The next step appears to have been the individualization, in amygdaloidal cavities, of *non-alkaline silicates*, viz: *laumontite*, *prehnite*, *epidote* respectively, according as the conditions favored the formation of one or the other of these.

Following these came the individualization of *quartz* in these cavities.

Perhaps we may be warranted in considering these minerals, together with the lime of the calcite that more rarely occurs in this portion of the series, as chiefly due to the decomposition of the pyroxenic ingredient of the rock.

So far as we may infer from the tabulated results, the concentration of *copper* in the amygdaloidal cavities does not appear to have begun till after the formation of the quartz.

In this part of the series falls also the formation of a chloritic or green-earth mineral, which in some manner has displaced prehnite, quartz, calcite, and with which copper, when present, appears to stand in intimate relation. Subsequently to this came the individualization of the alkaline silicates, viz: analcite, apophyllite, orthoclase. Here also seems to belong the formation of datolite.

The alkaline silicates represent the period of decomposition of the labradorite ingredient of the original rock, and when they occur in the mass of the rock (as distinguished from veins), it is only where the alteration of the rock has proceeded so far, that the amygdaloidal form has merged into the brecciated through the enlargement and union of the cavities.

The fact that calcite occurs at almost every step in the paragenetic series, and forms one of the most common of the secondary minerals, is proof that carbonic acid was very generally present throughout the whole period of metamorphism; it was probably the chief mediating agent in the processes, without being sufficiently abundant to prevent the formation of silicates.

II. The change of pyroxene to chlorite, as illustrated on an immense scale in the formation of the melaphyr, and the displacement of feldspar and quartz—quartz-porphyry—by chlorite as exhibited in pebbles of the conglomerate, point to an extremely important line of investigation for the chemical geologist. The alteration of the pebbles appears to have fol lowed two different directions according to the ruling conditions, viz: either toward chlorite or toward kaolinization; and as the result of the latter process is impregnated with calcite while the result of the former is free from carbonates, it would seem that the direction was determined by the presence or relative freedom from free carbonic acid. The deposition of calcite, if formed from the acid carbonate, would set free sufficient carbonic acid to prevent the formation of silicates of iron and magnesia.

III. *Copper*, wherever we can detect it with the eye, has already gone through a partial concentration. The presence of this metal in minute quantity in the sandstones of Lake Superior, is made evident by the stains of carbonate which form on the cliffs of the "Pictured Rocks." It is found here and there in the less amygdaloidal melaphyr in minute specks and impregnations, or even in a more concentrated form as thin sheets occupying the joint-cracks.

These occurrences increase in frequency in proportion as the rock is more amygdaloidal; in other words, the copper is more concentrated in those portions of the beds where the chemical change has been greatest. Where the rock has not passed beyond the strictly amygdaloidal stage, the copper occurs in the amygdules traversing these in flakes, or coating them in a film of greater or less thickness, to such an extent as to form from ½ per cent to 3 per cent by weight of the rock over considerable areas. Finally, in those beds where the metamorphism has proceeded to such an extent as to wholly replace large portions of the amygdaloid by secondary minerals, epidote, calcite, quartz, chlorite, laumontite, etc., there the copper occurs in masses of many pounds, and sometimes of several tons weight, and in forms equalled in their irregularity only by those of the masses of secondary minerals accompanying the metal.

In each and all of these positions we find that the deposition of the copper took place subsequently to the decomposition and removal of a portion of the rocks, and subsequently to the deposition of laumontite, epidote, prehnite, and quartz, where these accompany it.

In all this we have direct evidence of the movement of some salt of copper in wet solution, and the concentration of the metal by accumulating deposition in places where the precipitating agent existed.

The Quebec group, to which these rocks belong, and which consist in various places of undoubted sedimentary strata exhibiting every degree of metamorphism, is as strongly characterized by copper as the Galena limestone is by lead.

Except in the melaphyrs of Lake Superior, the copper, so widely diffused in the strata of the Quebec group, exists either in the various suphurets, or as oxidation products of these. Indeed we cannot well suppose the copper to have been deposited in submarine formations in any other condition than as sulphuret. Nor can we suppose it to have taken any other form permanently, so long as unoxidized organic matter remained in the beds. An oxidation of the sulphuret would be followed by reduction of the resulting sulphate to new sulphurets around the organic remains. In this way we may suppose the simplest and most common form of concentrated deposits —the impregnations—to have originated, as well as the farther enrichment of particular beds or zones—*fahlbands*—which may represent strata which were originally richer in organic substances, or which may have retained these longer than the other beds.

The trappean series of Keweenaw Point differ from the general character of the rocks of the Quebec group, both in lithological constitution and in having the copper in the metallic state. It is still an open question whether the trap which formed the parent rock of the melaphyr was an eruptive or a purely metamorphic rock. If it was eruptive, it was spread over the bottom of the sea in beds of great regularity, and with intervals which were occupied by the deposition of the beds of conglomerate and sandstones.

But the general diffusion of copper through the varied rocks of the Quebec group, speaks for a marine origin for the metal in these traps. It should seem probable that the copper in the melaphyrs was derived by concentration from the whole thickness of the sedimentary members of the group, including the thousands of feet of sandstones, conglomerates and shales which overlie the melaphyrs and including melaphyrs also—and especially, if these are purely metamorphic.

Among the most interesting questions connected with the occurrence of the copper, are those touching its condition previous to concentration during the amygdaloidal stage of metamorphism, the chemical combination by which this concentration was effected, and the character of the precipitating agent.

The great persistency of metallic sulphurets through the usual processes of metamorphism, and the almost universal association of sulphur with copper in crystalline rocks, renders it perhaps probable that this was here also the combination in which the metal was diffused, or rather, very partially concentrated. Traces of sulphur detected by Mr. Hochstetter in the melaphyr contiguous to the Hecla conglomerate point also in this direction, considering that the only acids generally present in the melaphyrs are silicic and carbonic acids, and if we add sulphuric acid as an oxidation product of the sulphurets, our choice of the form of solution, by which the final concentration was effected, should seem to be limited to silicates, carbonates, and sulphates of copper. Probably all of these combinations took part in the process, but while we may consider the translocation of the copper to have been initiated by the sulphate, this salt must have been so soon decomposed by the abundant acid carbonate of lime* as well as by the alkaline silicates, that we cannot readily suppose the sulphate† to have generally effected the final concentration of large deposits. It is more probable that this was accomplished by the more permanent solutions of carbonate and silicate of copper respectively, as the circumstances favored. The position of the metallic copper in the paragenetic series shows it to have been deposited after the non-alkaline silicates, and before the formation of the alkaline silicates, i. e., after those minerals which resulted from the decomposition of the pyroxenic constituent of the rock, and before those which were formed by the destruction of the feldspar. Now this is what we should expect if we suppose the pyroxenic rock to have been altered to its present condition under the coöperation of water carrying carbonic acid and some free oxygen, because the oxygen must have been employed in oxidizing the carbonate of iron resulting from the decomposition of the pyroxene;‡ the oxidation of the sulphuret of copper could not, therefore, take place until the pyroxene had so far disappeared as to leave a relative excess of oxygen as compared with the amount of ferrous salts exposed to a higher oxidation. Throughout its deposits the copper exhibits a decidedly intimate connection with delessite, epidote and green-earth silicates, containing a considerable percentage of peroxide of iron as a more or less essential constituent; while among the other silicates, viz: analcite, laumontite, datolite, prehnite, only the last named, which alone seems subject to a considerable replacement of its alumina by ferric oxide, is especially favored by copper. This association is so invariable and so intimate that one is forced to the conclusion that there exists a close genetic relation between the metallic state of the copper and the ferric condition of the iron oxide in the associated silicates; that the higher oxidation of the iron was effected through the reduction of the oxide of copper and at the expense of the oxygen of the latter.

As regards the green-earth and that variety of chlorite or delessite which is intimately associated with the copper, they either immediately follow the copper in point of age or are contemporaneous with it, and they may be looked upon as having been formed under the influence of this reduction. Where copper is associated with prehnite it is invariably younger than the latter, a fact which would seem at the first glance to oppose the supposition that there is any relation between the peroxide of iron in the zeolite and the deposition of the copper. But we have seen that prehnite undergoes a change to delessite; we find these pseudomorphs in every stage of the process from the first green discoloration on the cleavage planes to the amygdule of delessite with prehnite structure. Now may we not consider the presence of iron in prehnite generally to be due to a beginning change, and the deposition of native copper in the Lake Superior prehnites to be partially or wholly correlated with the higher oxidation of the iron? In at least very many instances, if not in all, the deposition of the copper has been a result of a process of displacement of preëxisting minerals. In some rare instances the metal retains the form of its more or less remote predecessor, as in the pseudomorphs after some mineral (clay?) after laumontite.

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* A coating of gypsum covering very thin sheets of copper from the jointing-cracks of the melaphyr contiguous to the Hecla conglomerate, may be due to this decomposition, followed by the reduction of the copper.

† Compare Bischof Chem. u. Phys. Geol., I, p. 52, and III, p. 716.

‡ The result of this oxidation is seen in the brick-red color of the amygdaloids and in the brown color and spots of many of the melaphyr beds.

Nowhere is this displacement more apparent than in the cupriferous conglomerates. In these the cement is the home of the metal, and in some places, as in portions of the Hecla and Calumet mines, it is wholly replaced by it; copper forming 20 to 50 per cent, by weight, of the rock. In these instances either chlorite or epidote is associated with the copper as minerals formed since the deposition of the conglomerate, while calcite very frequently replaces the cement in barren portions of the bed.

The cement of the conglomerates is of the same materials as the pebbles in a more comminuted form. The displacement of the whole mass of quartz porphyry in large pebble by chlorite and copper described above, is probably an illustration of the manner in which the cement was displaced on a more extended scale.

The absence of the ores of the baser metals—lead, zinc, nickel, etc., from the deposits of the trappean series, while they are present in the less metamorphosed rocks of the Quebec group in other localities, may be due to the greater intensity of the chemical action to which the melaphyrs have been subjected; an intensity which may be measured by the extent to which the process of concentration has been carried. Concentration is a process of removal relatively speaking, and concentrated deposits are accumulated masses of material arrested in the drainage channels of rock masses by the action of competent forces; if the arresting cause is absent from a given region, the removal will continue to another where it is present. If causes exist which are able to arrest one class of the substances in the passing solution, and are powerless as regards another class, then a separation will occur between the two classes.

Now, copper and silver belong to a class distinct from the baser metals in that, by reason of their smaller affinity for oxygen, they are more readily reduced to the metallic state, the condition of greatest permanence in presence of the usual reagents to which they are exposed. If the arresting cause of these metals was, as we have supposed, their reduction by protoxide of iron, it is a cause which would have been powerless as regards the salts of the baser metals, and we may suppose these to have continued in solution till they reached some region where they were arrested by the presence of organic matter, or of sulphureted hydrogen, etc.

Art. XLVII.—*Observations on the color of Fluorescent solutions*—No. II; by Henry Morton, Ph.D., President of the Stevens Institute of Technology.

Since the publication of my article on the above subject, in the August number of this Journal, I have discovered a curious action which, while it in no respect affects my general conclusions, nor the main observations on which they were founded, throws out one of the corroborative experiments by which I thought that they might be established when a spectroscope was not at hand.

Obtaining some very anomalous results of late, I was led to mistrust the action of the Geissler tubes in which the solutions had been examined.

They were of the ordinary kind of jacketed spirals, selected as being nearly identical in size and other particulars.

It had been observed from the first that the internal spiral gave a faint blue fluorescence which could only be seen on close inspection; and in all cases, the tube being but partly filled, it was considered that a light appearing in the part covered by the fluid, many times more bright than that from the uncovered part of the spiral, was sufficient evidence of fluorescence in the liquid.

Late experiments have, however, proved that this was not so. Any liquid, however devoid of fluorescent properties, gives all the appearance of fluorescing in these tubes, and on a little thought the cause of this became clear.

The only fluorescent light that can be seen from the glass of the spiral is that which comes off tangentially from the outer surface, that emitted radially being marked by the bright electric discharge behind.

In passing from the glass to air, most of the light will suffer total reflection at the outer surface of the glass, but if water or any other liquid is substituted for the air, its greater refracting power (approaching that of glass) will diminish the above named action, so that much more of the light will reach the eye. The truth of this explanation was supported by the observation that the nearer the index of refraction in the liquid came to that of glass, the brighter was the light seen through it, while a liquid of higher refraction, like carbon bisulphide, seemed a little to weaken the effect by diffusion.

This fact renders of no account the observations before made on filtered and diluted solutions of turmeric, but a fresh observation with the spectroscope on tubes free from fluorescence has fully confirmed my former conclusions as to the true color of fluorescence in this liquid.

No correction need be applied to the description already published in the case of the asphalt solution, but I may add to what was there stated another striking example.

If one of the little Geissler tubes containing nitrogen, called "spectrum tubes," be jacketed by means of a perforated cork and a large glass tube, and the jacket filled with pure or non-fluorescent benzine, then illuminating the tube, and with a pipette dropping in that petroleum product called "cosmoline" (a lubricating oil made by E. H. Houghton, of Philadelphia), each drop will appear of a rich blue as it dissolves in the benzine, which soon acquires a magnificent blue fluorescence. Increasing, however, the quantity of cosmoline oil until its color begins to take effect, the tint of the fluorescence gradually changes to a rich green.

By a little care a blue solution may be superposed on a green one in the same tube.

Another semi-solid preparation of cosmoline, which has a very light color, gives a solution with benzine fluorescing of a magnificent blue.

I have this substance now under investigation, and hope soon to be able to make some further observations upon it.*

Returning to the solutions of turmeric, I have found that the fluorescent body in that substance is not its essential oil nor its brown coloring matter, but either the yellow coloring matter itself, or something so closely allied to it in solubility that I have thus far been unable to effect any separation.

In connection with this, let me say that I am much indebted to Mr. Robt. F. Fairthorne, of Philadelphia, who has aided me greatly in the preparation of the various constituents of turmeric in a state of purity.

In my former paper I mentioned that uranium nitrate in solution gave a very faint fluorescence.

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* Mr. Houghton tells me that "cosmoline" is prepared from crude petroleum by evaporation in vacuo and filtration through animal charcoal only, without any chemical treatment.

This appearance I now find was due entirely to the above explained action of the tube, and a number of carefully conducted observations now convince me that this substance, while it fluoresces so vividly in the solid state, loses that property entirely when in solution.

I have also found that a saturated solution of acid quinine sulphate has its fluorescence much *increased* by dilution.

Lastly, let me remark that I by no means assert that *all* solutions fluoresce blue, but simply those which I have examined. There are many which I have as yet been unable to procure or study, whose relations in this respect I hope soon to investigate.

ART. XLVIII.—*Brief Contributions to Zoölogy from the Museum of Yale College.* No. XVI.—*On the Distribution of Marine Animals on the southern coast of New England;* by A. E. VERRILL.

IN connection with the investigations concerning the fisheries under the direction of Professor S. F. Baird, U. S. Commissioner, thorough explorations of the adjacent waters were undertaken in order to ascertain the character of the bottom, and the distribution of the lower animals, especially of those that furnish food for certain fishes. The Fish Commission had its headquarters at Wood's Hole, Mass., situated on the point of land between Vineyard Sound and Buzzard's Bay. In addition to the shore collections, extensive and systematic dredging operations were undertaken by means of a steam-launch in the waters of Vineyard Sound and Buzzard's Bay, and by the aid of a U. S. Revenue Cutter, the steamer "Moccasin," the dredgings were carried outward to the deeper parts of Muskeget Channel, situated off Martha's Vineyard, and from thence to a point off the mouth of Buzzard's Bay.* These explorations were made by means of dredges of several different sizes, of the usual forms; a rake-dredge of novel construction, especially adapted to soft muddy bottoms; an iron frame to which unraveled ropes, or "tangles," were attached for use on rocky bottoms; a large trawl-net; surface towing-nets for swimming creatures, etc.† The points where dredgings were made were carefully located on Coast Survey charts, and were sufficiently numerous to give a satisfactory knowledge of the nature of the bottom and its inhabitants throughout the region explored. The total number of hauls of the dredges, during the three months, was about four hundred. The surface dredging also yielded many things of great interest.

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* The dredgings in the first part of the season were made under the direction of Mr. S. I. Smith, and later by Professor J. E. Todd, Professor A. Hyatt, Dr. A. S. Packard, and the writer, all more or less aided at various times by other naturalists, and especially by Dr. W. G. Farlow, who collected the algæ.

† Some of these instruments will be described in a future number of this Journal.

At this time I wish to call the attention of zoölogists to one of the most important of the results of these investigations, leaving a full account of the large and valuable collections for another occasion. The discovery referred to is that while the shores and shallow waters of the bays and sounds, as far as Cape Cod, are occupied chiefly by southern forms, or the Virginian fauna, the deeper channels and the central parts of Long Island Sound, as far as Stonington, Conn., are inhabited almost exclusively by northern forms, or an extension of the Acadian fauna.

There is also a corresponding difference in the temperature of the water, the change in some cases amounting to 5° F., both at the surface and bottom, within a distance of two miles and without much change in the depth. And consequently there must be an offshoot of the arctic current setting into the middle of the Sound, although the shores feel the influence of the Gulf Stream, as shown by the occurrence of southern forms of pelagic animals in their waters.

The shores of Buzzard's Bay and Vineyard Sound present nearly all varieties of stations, and are, therefore, favorable for collecting. They are occupied, except on some of the outer islands, by an assemblage of animals characteristic of the coasts farther south, and known as the *Virginian fauna.* A few northern forms occur, however, on the rocky shores, which do not extend as far as New Haven. Among these *Purpura lapillus* is most conspicuous. This shell is associated there with *Eurosalpinx cinerey*, in about equal numbers, but at New Haven the latter occurs alone, while on the northern coasts of New England the *Purpura* is found unaccompanied by the other, which is rarely found north of Cape Cod. But in nearly all other respects the littoral fauna is very similar to that of the vicinity of New Haven, or the coasts farther south, as far as Cape Hatteras, making allowance only for differences in the stations, and especially for the absence of rocks south of New York.

In Vineyard Sound and Buzzard's Bay the water is everywhere shallow, usually from 3 to 8 fathoms deep, and rarely exceeding 12 or 14 fathoms, even in mid-channel. In Vineyard Sound the bottom is generally sandy, and extensive reefs of shifting sand are numerous, and often nearly destitute of life. But extensive regions of gravelly and shelly bottoms occur, and these are often almost completely covered by several species of compound ascidians, growing in large masses. One of these, which forms large hemispherical or irregular masses, made up of an aggregation of long slender colonies, united together at their bases and usually thickly covered throughout with sand, is very abundant, often entirely filling the dredge with masses up to six inches in diameter. This is the *Amouroucium pellucidum* Verrill. Another one, nearly as abundant, forms smooth, cartilaginous masses in the form of flat lobes, crests, and plates, sometimes two feet long and about an inch thick, the surface covered with stellate colonies, while the color of the masses is of a delicate bluish or sea-green tint by reflected light, although yellow by transmitted light. This is *Amouroucium stellatum* V., described with the last in a former number of this Journal. A third species[*] of the same genus is also common, although still undescribed. This forms smooth gelatinous masses, varying from light orange to pale yellowish in color, with beautifully stellated colonies over its upper surface. With these were several simple ascidians, chiefly *Cynthia partita*[†] Stimp., and *Molgula Manhattensis* V., while creeping over them was a beautiful green species of *Perophora*,[‡] which is the first representative of the social ascidians discovered on our coast. This species also occurred in abundance on the piles of the government wharf at Wood's Hole, associated with the three last named. In the interstices of *A. pellucidum* were numerous annelids of several species, and growing upon or with the ascidians were many species of hydroids, bryozoa, and sponges. Among the sponges a massive sulphur-yellow species (*Spongia sulphurea* Desor) is very conspicuous. While young this species perforates and destroys dead bivalve shells, but later in life grows up into hemispherical or irregular masses. Upon the same bottoms were found the common southern greenish star-fish (*Asterias arenicola*), *Amphipholis elegans*, *Gouldia mactracea*, *Eulima oleracea* on *Thyone briareus*, *Anachis avara*, *Columbella lunata*, *Cancer irroratus*, *Libinia canaliculata*, *L. dubia*, *Eupagurus pollicaris*, *E. longicarpus*, and many other less common species. On rocky and stony bottoms, and especially in the tide-way of the channel at Wood's

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[*] ***Amouroucium constellatum***, sp. nov. Masses thick, turbinate, often encrusting, surface usually convex, smooth, substance firm, gelatinous, translucent, but softer than in *A. stellatum*. Systems stellate, circular, oval or elliptical, often elongated, or irregular and complex. Zoöids much elongated, slender, the branchial tube short with six rounded lobes. Branchial sac elongated. Color of the masses usually light orange-red, varying to yellowish and pale flesh-color; the branchial orifices with six radiating white lines. Zoöids generally orange-yellow; the orifices and tubes with upper part of mantle bright orange, or lemon-yellow; branchial sac usually flesh-color or pale yellow, sometimes bright orange; stomach with bright orange-red glandular ribs; mantle with minute opaque white specks.

[†] *Cynthia stellifera* V. proves to be a depressed variety of this species.

[‡] *Perophora viridis*, sp. nov. Individuals small, about ·10 to ·12 of an inch high, connected by slender stolons, and thickly covering the surfaces over which they creep. Test compressed, seen from the side scarcely higher than broad, oval, elliptical, or subcircular, often one-sided or distorted, with a short pedicle or subsessile at base. Branchial orifice large, terminal; anal lateral or subterminal, both a little prominent, with about 16 angular lobes, alternately larger and smaller. Test transparent; mantle beautifully reticulated with bright yellowish green; intestine yellow.

Hole, the southern purple sea-urchin (*Echinocidaris punctulata*), the orange star-fish (*Cribrella sanguinolenta*), the green star-fish, the coral (*Astrangia Danæ*), and many other interesting species occurred. All the species referred to, excepting the widely diffused species of *Cribrella* and *Amphipholis*, are either characteristic southern forms or else species that are not yet known except from the region explored. Several species were also obtained in Vineyard Sound which had not previously been found so far northward. Among these the flat sea-urchin with five perforations (*Mellita pentapora*) is especially worthy of mention, as it has hitherto been regarded as peculiar to the Carolinian fauna.* The free-swimming forms taken at the surface in this region were also numerous, and are likewise chiefly southern species, or if new they belong to southern types. Among the most interesting were *Salpa Cabotii*, which occurred in vast quantities about the first of September, and was found in abundance off Gay Head, as well as in the Sound; a splendid species of *Saphirina*, reflecting brilliant blue and red colors like a fire opal, which occurred mingled with the *Salpæ;* a new free-swimming crab; *Idotæa robusta* Kr.; innumerable young lobsters, crabs, and shrimp, in the zoea and megalops stages of growth; numerous jelly-fishes, among which *Mnemiopsis Leidyi* was perhaps the most abundant, but a species of *Cyanea* and *Dactylometra quinquecirra* were common, and both frequently gave shelter to several young "butter-fishes" (*Poronotus triacanthus*) of all sizes, from those just hatched up to two inches or more in length. In some cases twenty or more were found together under one jelly-fish. They also occurred, in the evening, under *Zygodactyla Grœnlandica* earlier in the season. The "Portuguese-man-of-war" (*Physalia arethusa*) was met with several times. Two Pteropods not before recorded from the United States coast were obtained,—one of them (*Stiliola* sp.) living, associated with *Salpa;* but of the other (*Cavolina tridentata*) the shells only were dredged, but in a very fresh condition.

In the deeper outer channels, as between Gay Head and Nomans-land, and at nearly all points outside of the latter, where the water is more than ten fathoms in depth, the fauna is very different from that of the sounds and bays, and closely resembles that of Massachusetts Bay and the coast of Maine. The difference in the temperature of the water is also well-marked. The surface temperature, during the latter part of August, was 69° to 71° in Vineyard Sound. On Sept. 9th, in the mouth of Vineyard Sound, west from Gay Head, the surface temperature was 67° F., and the bottom, in 15½ fathoms, was 63°; but proceeding about two miles farther out, off No-mans-land, the surface temperature was 62°, and the bottom, in 18 fathoms, was 58½°, showing a decrease of 5° within this short distance, both at the surface and bottom. A few miles farther out, at the same depth, the bottom temperature was 57°, which was the lowest temperature obtained. A short distance west of No-mans-land, on a gravelly bottom in 11 fathoms, where cod-fish are caught in winter, the temperature was 63° at the surface and 59° at the bottom. Off the mouth of Narragansett Bay, about sixteen miles south from Newport, the depth over a limited area is 29 fathoms, which was the deepest water found. At this locality the surface temperature was 62° and the bottom 59°. The bottom, in these deeper waters, was generally composed of soft mud, filled with innumerable tubes of worms and Amphipod crustacea, among which a species of *Ampelisca*, which makes a soft flabby tube, two or three inches long and covered with mud, is extremely abundant. At the last named locality numerous specimens of the rare and beautiful *Epizoanthus Americanus* V. was found coating the shells inhabited by hermit-crabs (*Eupagurus Bernhardus*) and finally absorbing the shells entirely. This remarkable Actinian has been found previously only on two occasions,—first on a deep bank off the coast of New Jersey, by Capt. Gedney; and since in deep water off Massachusetts Bay. With this was also found a rare Holothurian (*Molpadia oölitica*), previously known only from specimens taken from fish stomachs.

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* This and *Lytechinus variegatus* were found by the writer, Mr. S. I. Smith, and Prof. J. E. Todd at Great Egg Harbor, N. J., last spring, but they are very rare at that locality.

The various muddy bottoms in the deeper and colder areas yielded nearly the same assemblages of animals, most of which are either strictly northern types, many of them not before observed so far south; or else species of wide range extending much farther north as well as south. Among those of special interest are the following: of RADIATA, *Edwardsia farinacea* V., previously known only from the Bay of Fundy, *Thyonidium* sp.; of MOLLUSCA, *Molgula pilularis* V. and *Glandula mollis* Stimp., both known before only from the Bay of Fundy, *Cyprina Islandica*, *Cardita borealis*, *C. Novangliæ*, *Yoldia sapotilla*, *Y. limatula*, *Nucula proxima*, *N. delphinodonta*, *Cardium pinnulatum*, *Astarte quadrans*, *A. castanea*, *A. lutea* (?) Perkins, *Lyonsia hyalina*, *Anatina papyracea*, *Lucina filosa*, *Callista convexa*, *Crenella glandula*, *Modiolaria nigra*, *M. corrugata*, *Pecten tenuicostatus* (young = *P. fuscus* Lins.), *Buccinum undulatum*, *Chrysodomus pygmæus* (large and abundant), *Crucibulum striatum*, *Margarita obscura*, *Cylichna alba;* of ANNELIDS, *Clymene torquata* Leidy, *Ophelia simplex* Leidy ?, *Trophonia* sp., *Sternaspis fossor*, *Aphrodite aculeata* (large and common), *Nephthys* (large species), *Sipunculus Bernhardus*, and species of *Nereis*, *Lumbriconereis*, *Aricia*, etc.; of CRUSTACEA, species of *Ampelisca* (abundant), *Unciola irrorata*, and several other Amphipods. *Crangon vulgaris*, *Pandalus annulicornis.* On sandy bottoms *Echinarachnius parma* was very abundant, as it was, also, everywhere in the sounds, for it is a widely diffused species, occurring as far south as Great Egg Harbor; *Molgula arenata* St. also occurred, with a few other species of interest. A large species of sandy *Foraminifera*, often a quarter of an inch in diameter, was abundant. In the channel between Gay Head and No-mans land the bottom is gravelly and stony, and here some very interesting species were found; among the RADIATA were *Alcyonium carneum* Ag., *Edwardsia* (new species), *Grammaria gracilis* St., and many other hydroids, *Cribrella sanguinolenta*, *Asterias vulgaris* V., *Ophiopholis aculeata* Gray, *Euryechinus Drobachiensis* V.; of ASCIDIANS, *Amouroucium pallidum* V., *Molgula papillosa* V., *Cynthia carnea* V., *C. hirsuta* Binney, *C. partita* St., all northern species except the last; of shells many of the northern forms already named and some additional species; of CRUSTACEA, *Eupagurus Bernhardus*, *Cancer borealis* (thrown on shore and fragments dredged), *C. irroratus*, with numerous *Amphipods.*

The brief lists of species given above are quite sufficient to show the marked northern character of the fauna in the deeper waters of this region. Several of the northern shells enumerated above have also been dredged by Mr. Sanderson Smith in Gardiner's Bay, L. I., and some of them have long been known from Montauk Point. Mr. Linsley, in his catalogue of the shells of Connecticut,* also records many of the same northern species with a few additional ones, from Stonington. I have been informed by Mr. H. C. Trumbull, who collected the shells attributed to Stonington, that all these northern species were obtained by him from the stomachs of haddock, &c., which were taken within a few miles of Stonington. This would indicate that the northern cold current has a decided influence as far westward as that locality, beyond which its influence has not yet been traced.

SCIENTIFIC INTELLIGENCE.

I. CHEMISTRY AND PHYSICS.

1. *On nitrous and hyponitric acids.*—HASENBACH has repeated the experiments of Nylander on the nature of the red vapors formed in the oxidation of arsenous by nitric acid. By condensing these vapors, Nylander obtained a blue liquid boiling at 13° C., which appeared to have the formula $N\Theta_2$, and therefore to be isomeric with hyponitric acid. Hasenbach employed an apparatus constructed entirely of glass, and dried the liquid product ob-

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* This Journal, I, vol. xlviii, 1845.

tained with calcined cupric sulphate. The deep blue liquid obtained began to boil at 2° C., giving off much nitric oxide; the thermometer then rose rapidly to 10° C.; between 10° and 13° but little nitric oxide was given off. Between 13° and 22° the temperature rose rapidly, and at 22° the remaining portion of liquid passed over with the brown-red color of hyponitric acid. As the author could obtain no liquid with a constant boiling point between 10° and 13°, this portion of liquid was analyzed and found to have nearly the composition of hyponitric acid, $N\Theta_2$. The vapor density of this liquid, 2·177, also corresponded with that of hyponitric acid, which is 2·061 as calculated from the formula. The vapor when passed through a heated tube became colorless, but the color appeared again in the colder portion of the tube. Further investigation proved that the compound boiling between 10° and 22° was a mixture of much hyponitric with a little nitrous acid. The general results of the author's investigation are as follows:

(1.) The assumption of Nylander that in the oxidation of arsenous by nitric acid, of density 1·33, an isomer of hyponitric acid is formed, is without foundation. In this case, according to the concentration of the nitric acid, either hyponitric acid, or a mixture of nitrous and hyponitric acid, is formed.

(2.) Hyponitric acid and nitric oxide unite at a high temperature to form nitrous acid, which may in this manner be prepared chemically pure.

(3.) Hyponitric acid and chlorine under the same circumstances unite to form chloronitric acid, $N\Theta_2Cl$.

(4.) Bromonitric acid, $N\Theta_2B_2$, could not be obtained pure by this process, as the product is decomposed by boiling.

(5.) Iodine and hyponitric acid do not combine at a high temperature.

(6.) Cyanogen and hyponitric acid give, with the aid of heat, a highly explosive compound, perhaps cyanonitric acid, $N\Theta_2Cy$.

(7.) Chlorine, bromine and cyanogen do not unite in the cold with hyponitric acid, or do so only to a very limited extent.

(8.) Nitrous acid and oxygen unite at ordinary temperatures to form hyponitric acid.

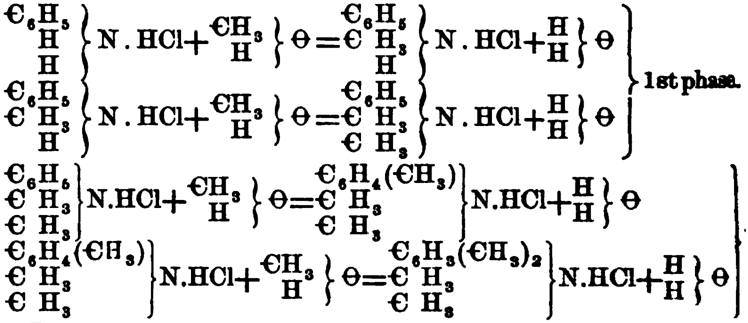
(9.) Sulphurous acid and carbonic oxide unite with hyponitric acid, even at a low temperature, to form compounds not further investigated.

All these facts speak in favor of the assumption that the molecule of fluid hyponitric acid is $\left\{\begin{matrix}N\Theta_2\\N\Theta_2\end{matrix}\right.$; that of the vapor above 100°, on the contrary, $N\Theta_2$.—*Journal für prakt. Chemie, Band* iv, p. 1. (New Series.) W. G.

2. *New method of separating magnesia from potash and soda.*—Scheerer separates the alkaline metals from magnesia in the following manner: The solution of the chlorides of the bases which may contain ammoniacal salts is to be evaporated, in a platinum vessel, not quite to dryness; a larger quantity of powdered ammonic oxalate is then to be stirred in, the whole heated to perfect

dryness, and finally gently ignited, care being taken to expose every portion of the saline mass to the same high temperature. The mass is then to be heated with water—heated to the boiling point and filtered. The magnesia remains on the filter as carbonate, while the alkalies are present in the filtrate as carbonates perfectly free from magnesia. The separation here depends, partly upon the formation of magnesic oxalate, which is decomposed by ignition into carbonate, partly upon the fact that the temperature at which ammonic oxalate is decomposed is higher than that at which ammonic carbonate is volatalized. The ammonic oxalate must of course be so pure as to leave no residue on ignition. In the presence of sulphuric acid the method is not applicable, probably because the ammonic sulphate is decomposed after the oxalate. —*Journal für prakt. Chemie, B.* iii, p. 476. W. G.

3. *On the methylation of the phenyl group in anilin.*—**Berthelot** observed some years since that small quantities of ethylamin are formed by the action of alcohol upon ammonic chloride at a high temperature. The reaction, which in this case takes place with great difficulty, was employed by Bardes, chemical director of the anilin color factory of Poirrier and Chappat in Paris, for the production of methyl anilin, dimethyl anilin, ethyl anilin and diethyl anilin, methylic or ethylic alcohol and chlorhydrate of anilin being heated together. In this reaction, however, other products are formed at the same time with the salts above mentioned, and these have been examined by Hofmann and Martius, who operated upon very large quantities of material, repeating the process twice in succession upon the same material. The very beautiful and interesting results of this investigation are as follows: The methylation or ethylation takes place in two distinct phases, the first being the introduction of methyl or ethyl into the phenyl-ammonia; the second, the replacement of the hydrogen of the phenyl itself by methyl or ethyl. So far as the final results are concerned, these reactions may be expressed by the equations:



$$\left.\begin{array}{l}
\left.\begin{array}{l}\text{Є}_6\text{H}_5\\ \text{H}\\ \text{H}\end{array}\right\}\text{N . HCl}+\left.\begin{array}{l}\text{ЄH}_3\\ \text{H}\end{array}\right\}\text{Θ}=\left.\begin{array}{l}\text{Є}_6\text{H}_5\\ \text{Є H}_3\\ \text{H}\end{array}\right\}\text{N . HCl}+\left.\begin{array}{l}\text{H}\\ \text{H}\end{array}\right\}\text{Θ}\\
\left.\begin{array}{l}\text{Є}_6\text{H}_5\\ \text{Є H}_3\\ \text{H}\end{array}\right\}\text{N . HCl}+\left.\begin{array}{l}\text{ЄH}_3\\ \text{H}\end{array}\right\}\text{Θ}=\left.\begin{array}{l}\text{Є}_6\text{H}_5\\ \text{Є H}_3\\ \text{Є H}_3\end{array}\right\}\text{N . HCl}+\left.\begin{array}{l}\text{H}\\ \text{H}\end{array}\right\}\text{Θ}
\end{array}\right\}\text{1st phase.}$$

$$\left.\begin{array}{l}
\left.\begin{array}{l}\text{Є}_6\text{H}_6\\ \text{Є H}_3\\ \text{Є H}_3\end{array}\right\}\text{N.HCl}+\left.\begin{array}{l}\text{ЄH}_3\\ \text{H}\end{array}\right\}\text{Θ}=\left.\begin{array}{l}\text{Є}_6\text{H}_4(\text{ЄH}_3)\\ \text{Є H}_3\\ \text{Є H}_3\end{array}\right\}\text{N.HCl}+\left.\begin{array}{l}\text{H}\\ \text{H}\end{array}\right\}\text{Θ}\\
\left.\begin{array}{l}\text{Є}_6\text{H}_4(\text{ЄH}_3)\\ \text{Є H}_3\\ \text{Є H}_3\end{array}\right\}\text{N.HCl}+\left.\begin{array}{l}\text{ЄH}_3\\ \text{H}\end{array}\right\}\text{Θ}=\left.\begin{array}{l}\text{Є}_6\text{H}_3(\text{ЄH}_3)_2\\ \text{Є H}_3\\ \text{Є H}_3\end{array}\right\}\text{N.HCl}+\left.\begin{array}{l}\text{H}\\ \text{H}\end{array}\right\}\text{Θ}
\end{array}\right\}$$

It can, however, scarcely be doubted that methylic chloride and water are always formed first, and that methylic chloride is the true agent of substitution. In the basic oils submitted to examination, the authors discovered besides dimethyl anilin four other dimethylated monamines—namely, dimethylated toluidin, xylidin, cumidin and cymidin; in symbols the compounds:

Dimethyl—

Anilin, $\left.\begin{matrix}\text{€}_6\mathrm{H}_4\\(\text{€}\mathrm{H}_3)_2\end{matrix}\right\}\mathrm{N}.$

Toluidin, $\left.\begin{matrix}\text{€}_7\mathrm{H}_7\\(\text{€}\mathrm{H}_3)_2\end{matrix}\right\}\mathrm{N}=\left.\begin{matrix}\text{€}_6\mathrm{H}_4(\text{€}\mathrm{H}_3)\\(\text{€}\mathrm{H}_3)_2\end{matrix}\right\}\mathrm{N}.$

Xylidin, $\left.\begin{matrix}\text{€}_8\mathrm{H}_9\\(\text{€}\mathrm{H}_3)_2\end{matrix}\right\}\mathrm{N}=\left.\begin{matrix}\text{€}_6\mathrm{H}_3(\text{€}\mathrm{H}_3)_2\\(\text{€}\mathrm{H}_3)_2\end{matrix}\right\}\mathrm{N}.$

Cumidin, $\left.\begin{matrix}\text{€}_9\mathrm{H}_{11}\\(\text{€}\mathrm{H}_3)_2\end{matrix}\right\}\mathrm{N}=\left.\begin{matrix}\text{€}_6\mathrm{H}_2(\text{€}\mathrm{H}_3)_3\\(\text{€}\mathrm{H}_3)_2\end{matrix}\right\}\mathrm{N}.$

Cymidin, $\left.\begin{matrix}\text{€}_{10}\mathrm{H}_{13}\\(\text{€}\mathrm{H}_3)_2\end{matrix}\right\}\mathrm{N}=\left.\begin{matrix}\text{€}_6\mathrm{H}\ (\text{€}\mathrm{H}_3)_4\\(\text{€}\mathrm{H}_3)_2\end{matrix}\right\}\mathrm{N}.$

The terminal member of this group is still wanting, and would have the formula:

$$\left.\begin{matrix}\text{€}_{11}\mathrm{H}_{15}\\(\text{€}\mathrm{H}_3)_2\end{matrix}\right\}\mathrm{N}=\left.\begin{matrix}\text{€}_6(\text{€}\mathrm{H}_3)_5\\(\text{€}\mathrm{H}_3)_2\end{matrix}\right\}\mathrm{N}.$$

The authors remark that the names selected do not necessarily imply that the compounds are identical with those already known, since they may be only isomeric with them. Thus the xylidin already known may not give by methylation with methylic iodide a dimethyl xylidin identical with the above, but only one isomeric with it. Thus we already know a solid and a fluid modification of toluidin. By treatment with methylic iodide, solid toluidin yielded a dimethyl base, which in many respects resembled that mentioned above, but which yet did not appear to be certainly identical with it, although the tertiary monamines derived from both bases appeared to exhibit no differences whatever. The authors promise a further investigation of the whole subject, and chemists will look with the greatest interest for their results.—*Berichte der Deutschen Chem. Gesellschaft, Jahrgang* iv, p. 742. W. G.

4. *On the derivatives of hydric phosphide which correspond to ethylamin and diethylamin.*—A. W. Hofmann has succeeded in obtaining phosphorus compounds corresponding to ethylamin and diethylamin. The process consists in digesting an alcoholic iodide with iodide of phosphonium and a metallic oxide. When, for instance, one part by weight of zinc-white, four of iodide of phosphonium, and four of iodide of ethyl, are digested together for six to eight hours, at a temperature not exceeding 150° C., a nearly white crystalline mass is obtained, which is chiefly the iodide of ethly phosphin, the reaction being expressed by the equation:

$$2\text{€}_2\mathrm{H}_5\mathrm{I}+2\mathrm{Ph}_4\mathrm{I}+\mathrm{ZnO}=2\mathrm{P}(\text{€}_2\mathrm{H}_5)\mathrm{H}_3\mathrm{I}+\mathrm{ZnI}_2+\mathrm{OH}_2.$$

In this case, however, a certain quantity of diethyl phosphin is always formed, the reaction being expressed by the equation:

$$2\text{€}_2\mathrm{H}_5\mathrm{I}+\mathrm{PH}_4\mathrm{I}+\mathrm{ZnO}=\mathrm{P}(\text{€}_2\mathrm{H}_5)_2\mathrm{H}_2\mathrm{I}.\,\mathrm{ZnI}_2+\mathrm{OH}_2.$$

The tertiary and quaternary derivatives of phosphonium are not formed in this reaction. These, Hofmann had already shown, might be obtained by the action of the alcohols themselves on phosphonic iodide. The separation of the mono- and di- compounds is very easy. Water readily decomposes the first, setting the phosphine free, and leaving the latter unchanged in solution. The phosphine may then be separated by distillation, and dried by means of potassic hydrate. From the residue in the retort, the di-compound may be separated by distilling with caustic soda in an atmosphere of hydrogen. Monethyl phosphin, $\mathrm{P}(\text{Є}_2\mathrm{H}_5)\mathrm{H}_2$, is a colorless, transparent, mobile liquid, lighter than water, boiling at 25° C., without action on vegetable colors, and possessing a truly fearful odor. In contact with chlorine, bromine, iodine, and fuming nitric acid, it takes fire. It unites with sulphur and carbonic disulphide to form fluid compounds. With chlorhydric, bromhydric and iodhydric acids it unites to form salts. The chlorhydrate forms a beautiful carmine-red, crystalline salt with platinic chloride. Diethyl phosphin, $\mathrm{P}(\text{Є}_2\mathrm{H}_5)_2\mathrm{H}$, is a colorless, transparent, perfectly neutral liquid, insoluble in and lighter than water. It boils at 85° C., and has a penetrating and persistent odor. It oxidizes readily in the air, and sometimes even takes fire; it also unites with sulphur and carbonic disulphide to form fluid compounds. Diethyl phosphin unites with acids to form salts which, with the exception of the iodhydrate, are difficult to crystallize. Methyl phosphine, $\mathrm{P}(\text{Є}_2\mathrm{H}_5)\mathrm{H}_2$, is a colorless gas, with an odor even worse than that of the ethyl compound. It may be condensed to a liquid by cold or pressure. The salts of this base are decomposed by water. Dimethyl phosphin is a colorless liquid, insoluble in water, and boiling at 25° C. like its isomer ethyl phosphin. It takes fire when exposed to air, and forms very soluble salts with acids.—*Berichte der Deutschen Chem. Gesellschaft*, *Band* iv, pp. 430 and 605. W. G.

II. Geology and Natural History.

1. *Note on an Apparent Violation of the Law of Regular Progressive debituminisation of the American Coal beds comin East;* by J. P. Lesley. (Proc. Am. Phil. Soc., xii, p. 125, 1871. —In the course of a Geological survey of certain lands in Somerset county, Pennsylvania, it appeared that the beds of coal existing at Ursina held much less volatile matter than was expected The gas coals of Westmoreland county, which come east as fa as Connellsville, only thirty miles west of Ursina, hold betwee 30 and 40 per cent. of volatile matters. Three analyses show Ursina coals to have but 17 per cent., while a fourth gives 22 pe cent. This puts the Somerset county coals into the *semi-bitumi nous* class. Yet the specimens were taken from gangways, a goo many years old, and several hundred feet from the outcrop, unde high hill cover, at a point on the *western* border of the Firs Bituminous Coal Basin of Pennsylvania, near the Maryland an Virginia State line. More properly we should say that the Ursin coals lie in the second synclinal of the First Basin. For th Negro Mountain anticlinal comes up from Virginia and split the First Basin into two in Pennsylvania. The Mountain di down at Castleman's River; but the anticlinal axis runs

northward. The First Basin is similarly split into two, east of Johnstown, by the Viaduct anticlinal, which may or may not be an actual prolongation of Negro Mountain.

To make the situation understood, the following extracts from my report to the owners of the property will suffice. The accompanying map shows the Backbone of the Alleghany passing by Altoona. This is the eastern edge of the First Bituminous Coal Basin. The two long parallel mountains between Ursina and Connellsville enclose the Second Bituminous Coal Basin of Pennsylvania. The Third, Fourth and Fifth lie west of it, and the Sixth occupies the northwest corner of the map; no mountains separating the last four. [The map referred to is here omitted].

The property surveyed, in this instance, lies in my old tramping and camping ground of 1840, during the fifth year of the State Geological Survey. The report which Mr. James T. Hodge and myself made to Mr. H. D. Rogers, Chief of the Survey, may be found recorded in the Fifth Annual Report (1841), pages 89-92, which I will here recapitulate in the *descending* order of the beds, for convenience of comparison.

The Pittsburg bed, I, has been eroded from the whole country between the Alleghany Mountain and Chestnut Ridge (at Connellsville and Blairsville) except two hill tops; one near Salisbury, and the other near Ligonier. It is possible also that a third exception may be discovered in the high hill country south of Johnstown, where a conspicuous bench runs along the hill-tops for several miles.

Limestone 20 feet below I, 6 feet thick in the Ligonier Basin.

Coal bed H, 50 feet below I, 3 feet thick in the Ligonier Basin; 1 foot thick in the Salisbury Basin.

Coal bed G, 100 feet below H, 1½ feet thick in the Salisbury Basin; encircles the highest hill-tops in the Ursina Basin with a conspicuous bench. Fort Hill is not quite high enough to have it.

Red Shales between G and F.

Coal bed F, 90 feet below G; generally small; but 4 feet thick in the Salisbury Basin. It forms the high terrace of the Fort Hill.

Mahoning Sandrock.

Coal bed E, "Upper Freeport," 50 feet below F; 2 feet thick, on 2 feet of *Limestone* (over it Shales with *ore-balls*) in Ursina Basin; 3 feet thick, on 5 feet of *Limestone* in the Salisbury Basin.

Coal bed D, "Lower Freeport," 60 feet below E, 6 feet thick in Ursina Basin; 4 feet, farther north; over 10 feet of sandstone with *ore-balls*, in two beds, 7 feet asunder, 11 inches in all. This ore-ball horizon is very extensive north and south of the River.

Coal bed C, 20 feet below D, 2½ to 4 feet thick.

Coal bed B, 30 feet below C on Cox's Creek, 40 on Laurel Hill Creek (N. Fork), and 60 at Confluence; 4 feet thick over 8 feet of *Limestone* on the river; 1½ feet thick over 4 feet of *Limestone* on the North Fork. Twenty feet above B lie 15 feet of Shales, etc., containing *ore-balls*, on Spring Run, below Pinkerton's Bend of the river.

Coal Bed, 22 feet below Limestone, on west bank of Castleman's river, ¼ mile above Zook's Run ford, and on North Fork at old salt boring; carries 5 feet of Shale, containing 1 foot of *ore-balls*.

Coal bed A, 70 feet below B; 22 inches thick, at Shroff's Bridge over Castleman's river.

Conglomerate; 30 feet below A; the interval being massive sandstone.

Such was the general scheme of the Coal measures made out during the old survey, and, however subsequently modified, it has been of incalculable value in all subsequent special and private investigations. It was a very successful attempt to reduce to system the heterogeneous mass of details collected from all parts of the Bituminous Coal Region of western Pennsylvania outside, or to the east, of the Monongahela River Upper Coal Beds, and of the Alleghany River Lower Coal Beds. It was by the collation of these three generalizations, that the first knowledge of the true order of the American Coal Measures was obtained, a starting point and a basis for all the Western Surveys.

[The details with regard to the region and the beds of rock and coal are here omitted]. Analyses of specimens from one of the beds called the Ferriferous Bed afforded as a mean of two analyses:

Volatile matters and water	17·125
Water alone	
Fixed carbon	68·535
Ashes	14·34

A specimen from another opening, near the mouth of Brown's Creek, gave:

Water	0·55
Volatile substances (gas)	21·90
Carbon (coke)	60·98
Sulphur (in ash)	0·62
Ash	15·95

That both the 6-foot and the 3-foot Ursina beds, situated at the western limit of the 1st Bituminous Coal Basin, should have only 17 per cent. of volatile matters,—not more than the coals of the Broad Top Region lying one hundred miles to the east of Ursina—is truly remarkable. The Broad Top beds are tilted and faulted abundantly. The Somerset County beds are almost perfectly undisturbed. The coal in one gangway showed 22 per cent. of volatile substances. But even this is no greater than the coals of the Alleghany Mountains and the coals of the Cumberland Coal Region.

No proper scheme of the *rates* of *debituminization to easting* and to *disturbance*, can be obtained until all the analyses of each bed in the series of Coal Measures shall be tabulated apart from the rest. We may then expect to learn something also respecting the influence of specific vegetation upon the percentages of coke and gas.

But in the outset one source of error must be guarded against. The specimens of coal, from which the foregoing analyses were made, were obtained in the walls of old gangways. It is possible that they had been long enough exposed to the air to lose some of their hydro-carbons by spontaneous evaporation. The rate at which this goes on in coal mines and exposed heaps is variously stated by those who have investigated the subject.

Dr. Richters made a recent communication to a German Journal, in which he states his opinion that the weathering of coal depends upon its ability to absorb oxygen, converting the hydro-carbons into water and carbonic acid. At a heat, say of 375° F., only 5 or 6 per cent. of the carbon accepts oxygen; the rest seems to show little or no disposition to affine with it. The process is apparently dependent upon the per-centage of hydrogen. But with coal, cold or at ordinary temperature, the oxidation is so slow as to be imperceptible, even after exposure for an entire year. He says moisture has no accelerating effect, unless pyrites is present in quantity. Pure coal, heaped up for nine months or a year, unprotected by the weather and not allowed to become heated, is changed no more than it would be in a perfectly dry place.

Herr Grundmann, of Tarnowitz, on the other hand, has recently published elaborate experiments proving the effects of exposure on bituminous coals to be most serious. Coal which he exposed for nine months lost *fifty per cent.* of its value as fuel. His conclusions excited such doubts, that his experiments were repeated, in connection with Herr Varrentrapp, of Brunswick, who proved by laboratory experiments that oxidation took place at common temperatures. Three months sufficed to rob coal, kept uniformly at 140° C. (284° F.) of *all its carbon*, a heat less than that evolved in coal heaps exposed to the air.

Grundmann proved that the decomposition was the same in the middle of the heap as at the surface, and reached its maximum about the third or fourth week: that half of the oxygen was absorbed during the first fourteen days; that a coal poor in oxygen absorbs it most rapidly; that moisture is an important condition; that coals making, when freshly mined, a firm, coherent coke of good quality, make, after even only *eleven days* exposure, either no coherent coke at all, or coherent coke of quite inferior quality. For gas purposes, also, the coal is greatly injured.

It is evident that these facts have an important bearing on the value of the analyses given above.

2. *On the Oil wells of Terre Haute, Indiana;* by T. STERRY HUNT. Abstract of a paper presented to the American Association for the Advancement of Science, Indianapolis, Aug., 1871.—In previous publications I have endeavored to show that the source of the petroleum in southwest Ontario, and probably in some other localities, is to be sought in the oleiferous limestones of the Corniferous and Niagara formations, both of which abound in indigenous petroleum. I have, however, expressed the opinion that the overlying sandstones in Pennsylvania are also truly oleiferous.

In a paper read to this Association last year, I showed that the Niagara limestone at Chicago holds imprisoned in its pores an enormous quantity of oil, and remarked that the reservoirs which supply the wells in other districts are fissures along anticlinals, which, though sometimes occurring in strata above the oil-bearing horizon in Ontario, frequently occur in the Corniferous limestone itself. Hence the view held by some that the source of the oil in that region is to be sought in the overlying strata is negatived.

In Ontario there intervenes between the Corniferous and Niagara formations, the great saliferous series known as Onondaga or Salina formation. This, however, is wanting to the westward, where the first two formations come together, and according to Professor Cox, where exposed at North Vernon, Indiana, are both oleiferous.

A well lately sunk at Terre Haute, Indiana, in search of fresh water, has shown the existence of a productive source of oil in that region. It was carried 1,900 feet, and yields about two barrels of oil daily. A second well, a quarter of a mile east of north from the first, has given a supply of twenty-five barrels of oil daily. After passing through 150 feet of superficial sand and gravel, the boring was carried to a depth of 1,625 feet, where the oil was struck.

According to Prof. Cox, the strata passed through are as follows: Coal measures 700 feet; Carboniferous limestone, with underlying sandstone and shales, 700 feet; black pyroschists, regarded as equivalent of the Genesee slates, 50 feet. Beneath this, at a depth of twenty-five feet, in the underlying Corniferous limestone, the oil vein was met with.

The oil in the first well was found at the same horizon. A third well, about a mile to the eastward, was carried to a depth of 2,000 feet, but no traces of oil were met with.

This locality, on the Wabash river, is, according to Prof. Cox, on the line of a gentle anticlinal or uplift which is traced a long distance to the west of south. The relation of productive oil wells to such anticlinals was pointed out by Prof. Andrews and by myself in 1861.

Postscriptum.—In a note in this Journal for September (page 215), Mr. A. D. Warner refers to a paper by me on *The Oil-bearing Limestone of Chicago*, which appeared in this Journal for June (p. 420), and quotes from me as saying therein that "much of the petroleum of Pennsylvania, Ohio, and the adjacent regions, is indigenous to certain sandstones in the Devonian and Carboniferous rocks." It would have given a more correct idea of my views, had he cited the words preceding; after maintaining that a principal source of the petroleum is in lower rocks, in fact the limestone of the Niagara and Corniferous formations, I added: "There is however, reason to believe, as I have elsewhere pointed out, that much of the petroleum, etc." I there referred to the Geology of Canada, 1863-66, page 24, where I cite from two papers of J. P. Lesley (Amer. Phil. Society, x, 33, 187), and it is from the evidence there given by him, and not upon my own observations, iat I conclude “we have reason to believe” in the existence of idigenous petroleum in the sandstones in question. Lesley there ates that the oil in these rocks occurs in thin fissures corresponding to the remains of plant stems which have disappeared, having een converted into petroleum, an observation which is an answer Mr. Warner's remark that while the sand-rocks in question are een in certain parts to abound in fossil plants, “ they contain othing from which the petroleum could possibly have been de- ved”. While I have constantly maintained the view held by Ir. Warner, that the oil, so far as I have studied it, comes from a wer horizon, I am nevertheless not disposed to reject the state- ients of so skilled an observer as Mr. Lesley. Mr. Warner will nd in the facts ascertained at Terre Haute a confirmation of the iew that the petroleum in this region, at least, comes not from ie sandstone, nor even from the underlying pyroschists, but om the still lower limestones of the Niagara and Corniferous rmations.

Montreal, Sept. 8, 1871.

3. *Surface Geology of New Brunswick;* by G. F. MATTHEW, sq., (Proc. Nat. Hist. Soc. of New Brunswick, April, 1871.)—The ithor closes his paper with the following conclusions.

1st. The present summer climate of a large part of Acadia is ich as to compare with that of the region around Lake Supe- or, where according to Prof. L. Agassiz and Sir W. E. Logan, laciers existed during the Drift period. The resemblance in ie climatic conditions of the two regions is shown both by their iean summer temperatures and by the distribution of indigenous lants. (See Can. Nat., June, 1869.) The authority of Messrs. . Agassiz and J. D. Dana may be quoted in favor of the for- ier existence of glaciers in southern New England, which enjoys summer temperature considerably higher than Acadia.

2nd. Some of the phenomena of the drift epoch, such as the irection and position of the glacial striæ and the distribution of ie clays, do not appear susceptible of explanation on the hy- othesis that icebergs and ocean-currents alone produced them. nd it seems reasonable to suppose that a great sheet of ice milar to the continental glaciers of Greenland and the Ant- ctic regions, which will explain these phenomena, covered the ower Provinces during the glacial epoch; and that while the eneral course of this mass was southward toward the then exist- ig ocean, the motion of the deeply-buried ice in the bottom of ie glacier was partly governed by the configuration of the land eneath it.

3rd. That while the western portion of this icy mass was eadily moving down the Atlantic slope from the table land of rthern Maine, and the eastern pushing across the low swell of nd which separates the Gulf of St. Lawrence from the Bay of undy, the motion of the central portion of the ice-sheet, which uld have had but a slight inclination, would have been impeded nearly arrested by the southern hills of New Brunswick.

4th. That such portions of the glacier as were pushed over the tops of these hills, or through the narrow valleys between them, conformed in some degree to the slope of the surfaces over which they moved.

5th. The erosion effected by the glacier was chiefly in the softer rocks of the country; the harder ones resisting the attritive power of the ice, and preserving with comparatively little change their pre-glacial outline.

4. *Remarks on Fossil Vertebrates from Wyoming.* (Proc. Acad. Nat. Sci. Philad., August 8, 1871.)—Prof. LEIDY remarked that the collections of fossils presented this evening by Drs. J. Van A. Carter and Joseph K. Corsos were of unusual interest. They consist of remains mainly of turtles, with those of mammals and crocodiles, and were obtained from the tertiary deposits in the vicinity of Fort Bridger, Wyoming Territory.

The great abundance of remains of turtles, of many species and genera, of fresh-water and terrestrial habit, obtained in Wyoming, indicates this region to have swarmed with these animals during the earlier portion of the Tertiary period. Crocodiles and lacertian reptiles were likewise numerous. The many mammalian remains found in association with the reptilian fossils mainly belong to tapiroid and carnivorous animals.

The Wyoming tertiary fauna presents a remarkable contrast with the later faunæ of the Mauvaises Terres of White River, Dacota, and of the Niobrara River, Nebraska. Among the large number of fossils from these two localities, rich in evidence of mammalian life, there occur the remains of a single species of turtle in each, and none of crocodiles or other reptiles.

Dr. Carter's collection, besides containing remains of *Trionyx guttatus*, *Emys Jeanesianus*, *E. Haydeni*, and *E. Stevensonianus*, and *Baena arenosa*, also adds two new turtles to the list. One of these is a species of Emys of the largest size, and exceeds any now living. The carapace has measured about two feet and a half in length, and the sternum about two feet. In honor of its discoverer, it may be named *Emys Carteri*.

The first and second vertebral plates of this species present an unusual, perhaps an anomalous appearance. The first is 4 inches long, and clavate in shape, with the narrow part foremost. The second is 2¼ inches long, and presents the usual hexagonal form reversed. The third plate, a little longer, is quadrate, with convex sides. The first vertebral scute is vase-like in outline, 5½ inches long, 2¾ inches wide in front, 4¾ inches near the middle, and 3¼ inches at the back border. The second scute, of the ordinary form, is 5 inches long, and 4 inches wide.

The second turtle belongs to the recently characterized genus *Baena*, but is considerably larger than its associated species which have been described. The shell in its complete condition has been upwards of a foot and a half in length, and is seven inches and a half high. The sternum is flat, and about fifteen inches long. Its pedicles ascend at an angle of about 45°, and are seven inches and a half broad. As in the living *Dermatemys*, and the sea turtles, they are covered with large scutes, four in number, as in *Baena arenosa*. The intermediate vertebral scutes are longer than broad—the third being 4 inches long, and 3½ inches wide. A peculiarity of the species is the undulating manner in which the costal scutes join the marginal scutes, and the sternal scutes one another. The species may be named *Baena undata*.

Dr. Carter's collection also contains some fragments of bones of a large mammal, which are so mutilated as to be hardly characteristic. A jaw fragment among them, with the retained fragments of the true molars, would appear to indicate a species of *Palæosyops* much larger than *P. paludosus*. In absence of other evidence, it might be viewed as a species of this genus, under the name of *P. major*. The true molars occupied a space of four and a half inches. The last molar measured an inch and seven-eighths fore and aft, and an inch transversely in front.

Dr. Carter had also sent some fossils to Prof. Leidy, among which were portions of jaw, with nearly full series teeth of *Hyrachyus agrarius*. This animal is related to the Tapir, *Hyracodon*, and *Lophiodon*. The formula of its dentition is the same as in *Hyracodon:* 7 molars, 1 canine, and 3 incisors. The true molars are like those of *Lophiodon*, except that the last lower one has a bi-lobed instead of a triple-lobed crown. Apparently the same animal has been indicated by Prof. Marsh under the name of *Lophiodon Bairdianus*. A fragment of a lower jaw containing the last premolar, and the first true molar, indicates a larger species of *Hyrachyus*, which may be named *H. eximius*. The crown of the last premolar is 7½ lines antero-posteriorly, and 5½ transversely. The true molar has measured about 8½ lines fore and aft, and 6 lines transversely. The depth of the jaw fragment below the true molar is over an inch and a half.

Another fossil is a mutilated incisor, indicating a species of *Trogosus* rather more than half the size of *T. castoridens*, which may be named *T. vetulus*.

A femur of *Palæosyops paludosus*, in the collection, exhibits the third trochanter, characteristic of the unequal-toed pachyderms.

The astragalus of this animal almost repeats that of the living Tapirs.

Among the remains of Dr. Corson's collection there is the greater part of the lower jaw of a large crocodile, but too much broken to attempt to give an opinion in regard to its specific character, until it is in some degree mended or restored.

5. *Dredging in Lake Superior under the direction of the U. S. Lake Survey.*—Extensive dredgings were undertaken the past season in Lake Superior, from the U. S. steamer Search, under the direction of Gen. C. B. Comstock, Superintendent of the Lake Survey. Dredging was carried on from the shallow waters, especially along the north shore, down to 169 fathoms, the deepest point known in the lake. In all the deeper parts of the lake, the bottom, as shown both by the dredging and by the soundings

executed by the Survey, is covered with a uniform deposit of clay, or clayey mud, usually very soft and bluish or drab in color. Water brought from the bottom at many points was perfectly fresh; that from 169 fathoms gave no precipitate with nitrate of silver. The temperature, everywhere below 30 or 40 fathoms, varied very little from 39°, while at surface (at the time of the observations, during August) it varied from 50° to 55°. The fauna of the bottom corresponds with these physical conditions. In the shallow waters, the species vary with the varying character of the bottom, while below 30 to 40 fathoms, where the deep-water fauna properly begins, the species seem to be everywhere very uniformly distributed. The deep-water fauna, as might be expected from the unfavorable character of the bottom, is meager, and seems to be characterized rather by the absence of many of the shore species than by forms peculiar to itself. Some of the more interesting species occurring in deep water were: *Mysis relicta* Lovén, at various depths from 4 to 159 fathoms; *Pontoporeia affinis* Lindst., at nearly every haul from the shallowest to the deepest; a small undescribed species of *Pisidium*, down to 159 fathoms; several forms of dipterous larvæ, allied to *Chironomus*, down to the same depth; several species of Lumbricoid worms, of the genera *Tubifex*, *Sænuris*, and an allied genus; and a species of *Hydra*, which was found from the shore down to 159 fathoms. Of these, the *Mysis*, *Pontoporeia*, and *Pisidium* are identical with species found by Dr. Stimpson in his dredging in Lake Michigan, a short account of which was published in the American Naturalist for September, 1870. The species of *Mysis* and *Pontoporeia* I am unable to distinguish from specimens from Lake Wetter in Sweden. In the Swedish lakes, these species were associated with *Idotæa entomon* and *Gammaracanthus loricatus*, marine species, and were supposed by Lovén to have been derived from ancient marine species left in the lake basins by the recession of the ocean. The occurrence of these forms in Lake Superior, so far removed from the ocean, is certainly a very interesting fact in the geographical distribution of species, but one which I will not attempt to discuss in this brief notice. In the shallow waters many interesting species were obtained. Among these was a new species of *Crangonyx*, a genus closely allied to *Gammarus*, and heretofore known only from a few species found in the fresh waters of the old world, which occurred in 8 to 13 fathoms; and at the same depth, species of *Lumbricus*, *Nephelis*, *Procotyla*, *Gammarus*, *Asellus*, *Limnæa*, *Physa*, *Planorbis*, *Valvata*, *Sphærium*, *Pisidium*, etc. A full report will soon be published. S. I. SMITH.

6. *A. Featherman: Report of Botanical Survey of Southern and Central Louisiana.* In the *Annual Report of the Board of Supervisors of Louisiana State University, for year* 1870. New Orleans, 1871.—The Botanical Report, separately paged, fills 130 pages. Professor Featherman is Lecturer on Botany in the Uni-

versity, and Professor of Modern Languages. The general matter, which makes the principal staple of this Report, is of considerable interest, although the information afforded is in some cases decidedly trite. Our attention is concentrated upon the list of new species, twelve in number, which we enumerate, appending the names which they have previously received, some of them in works which Prof. Featherman has probably not had access to. We are indebted to the author for original specimens of some species and drawings of others, without which these determinations could hardly have been made. Taking the species in order:

Euphorbia Ludoviciana is *Phyllanthus Carolinensis* Walt.

E. Meganœsos is *E. maculata* L., a pretty well-marked, more erect, and smoothish variety, of our southern coast.

Sabbatia nana is *S. gracilis* Pursh, a dwarf form, approaching *S. stellaris*.

S. oligophylla is a slender state of *S. gentianoides* Ell.

Hydrolea leptocaulis is *H. affinis* Gray, Manual, ed. 5.

H. Ludoviciana is *H. ovata* Nutt.

Jussiæa Boydiana is *J. repens* L., a small form.

Tephrosia angustifolia, from the drawing is probably only a slender form of the next.

T. multiflora is *T. onobrychoides* Nutt.

Lilium Lockettii is *Crinum Americanum* L.

Œnothera paludosa, for lack of specimen and drawing, is not made out.

Helenium Seminariense is *H. nudiflorum* Nutt., that is, *Leptopoda brachypoda* Torr. and Gray. A. G.

7. *Dr. Rohrbach on Typha.*—Dr. Rohrbach, the monographer of *Silene*, of Berlin, has published a careful revision of the genus *Typha*. He recognizes 9 species, with 4 sub-species: 7 of the former are found in Europe, and 2 of these also in the territories of the United States, together with a sub-species, peculiar to the warmer parts of America.

Dr. R. has discovered that the fruits of 7 of the 9 species show a longitudinal groove, and burst open, emitting the seed, when placed in water: the two others possess no groove, nor do they open, the pericarp being adnate to the seed. Our species belong to the first section.*

The other characters on which he relies to distinguish the species are (1) the shape of the stigma, which is linear, spatulate or rhomboid; (2) the presence or absence of bracts (variable in shape in the same species) at the base of the female flower; (3) the proportional length of the stigmas, the perigonial hairs, and the just mentioned bracts, at the period of maturity of fruit; (4) the presence or absence of hair on the axis of the male inflorescence; (5) the pollen, whether in single grains or in 4 grains united; (6) the anatomical structure of the seed coats.

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* The species with adnate pericarp are *T. Laxmanni* Lepechin (the earlier name for *T. minor* Sm.), throughout middle and southern Europe and Asia; and *T. stenophylla* F. & M., extending from Asia into Italy.

The shape of the leaves, and the contiguity or distance of the male and female inflorescence, do not furnish very reliable diagnostics.

Typha latifolia Lin., throughout the United States to the Pacific, and into Mexico. Axis of male inflorescence hairy; pollen grains in 4's; female flowers without bracts; stigma lanceolate-spatulate, much longer than the perigonial hairs; leaves flattish.

Typha angustifolia Lin., in the northern parts of the United States, southward only known in Louisiana. Axis of male inflorescence hairy; hairs linear; pollen grains single; female flowers subtended by bracts, which are of equal length with the perigonial hairs, and much shorter than the linear stigma; leaves convex on back.

Typha Domingensis Pers., from Texas, through the West Indies, and southward (not in the Old World), is a sub-species of the latter. Hair of the male inflorescence tapelike, broader upward; perigonial hair of female flowers slightly clavate (not seen in any other typha); seed coat a little different from that of *T. angustifolia;* leaves almost flat. *T. Teuxillensis* and *T. Tenuifolia* H. B. K., belong here.

A plate elucidates the differences of structure of the seed coats. An alphabetical index enumerates the names and synonyms, and refers them to their proper places. G. E.

III. ASTRONOMY.

1. *Cordoba Observatory.*—The following are extracts from the recent official Report of the Director, Dr. B. A. GOULD.

The Observatory is situated on a height or barranca, lying to the southeast of the city of Cordoba, at a distance of eight squares from the principal Plaza, and not far from the gardens of the National Exposition.

The ground plan of the edifice consists of a square, divided into four rooms of $5{\cdot}8^m$ a side each; and forming wings to the E. and W. two more rooms of $3{\cdot}6^m$ wide by $4{\cdot}2^m$ long, destined for observations in the plane of the meridian; and, at the respective extremities of these, two circular towers $6^{m\cdot}$ in diameter each; while in the north and south direction two smaller towers of 4 meters in diameter serve as prolongations to the edifice. These towers have revolving cupolas, and the whole of the edifice forms a cross terminated at its four extremities by as many towers. Its entire length is about 38^m in the direction E. to W., by a width of $24{\cdot}3^m$ from N. to S. The height of the larger towers is 6^m and that of the small ones only $5{\cdot}4^m$.

Your Excellency knows that the materials for the rooms which lie toward the E. and for the towers to the N. S. & E. were sent from the United States in June of the last year, with the exception of the masonry, which it was necessary to have constructed upon the spot. These materials, forming thus two-thirds of the edifice, were received in Cordoba in the 3d week in October, and this part of the edifice at this day, if not completely finished, is, at least, in a state to be used. The remaining part, my friends in the United States, desirous to contribute to the good success and prompt realization of our establishment, have undertaken to contribute, and only thus has it been possible that these materials should be shipped in the first vessel which sailed this year from the United States for Rio de la Plata. I am notified that these were landed April 1st at Buenos Ayres; nevertheless the public calamity which has weighed upon that city and the restrictions which have, in consequence, been imposed on trade in other parts of the republic, have thus far delayed the reception of this last part of the edifice. When they reach us their putting together will be the work of a few weeks, thus completing the Observatory.

It would not be possible for me to recount here the efficient aid which your institution has received from its commencement as well from the authorities of the Province as from the citizens of Cordoba. The latter authorized me on my arrival to choose a lot of land of adequate size wherever it might be considered most convenient, and have since conveyed a square lot of $216{\cdot}9^{m}$ a side.

Our principal instruments, besides clocks, chronometers, chronographs and meteorological apparatus, are the meridian circle, the great equatorial, the small equatorial and the photometer. All these are now in the country; nevertheless we have not been able to avail ourselves of any one of them. Without an embargo, one month more will suffice in my judgment for their collocation.

Our meridian circle was made by Messrs. Repsold & Son of Hamburg, whose workshops are indisputably the most reliable for instruments of this class. The length of the telescope is $1{\cdot}484^{m}$; the aperture of its objective 122^{mm} and the divisions of the circles permit the appreciation of a single second by means of the microscopes. The whole apparatus is mounted on two pillars of white marble from the Sierra of Cordoba, which are laid in solid masonry cement, and are $1{\cdot}61^{m}$ high by $0{\cdot}71^{m}$ wide. Though not the greatest nor the most costly of our apparatus, nor indeed of the greatest magnifying power it is the principal instrument in a certain sense, since with it will have to be executed the greater part of our labors in the next 2 or 3 years. The great Equatorial is the principal instrument, if we take into consideration its imposing size and its magnifying power. Not having ordered it early enough, we had not supposed that it would be finished within the brief time at our disposal, yet I have had the fortune to be able to procure an objective of great excellence, the work of Fitz, a distinguished optician of New York. Its power has been tried by the astronomer Rutherfurd. The celebrated mechanicians, Clark & Sons, have undertaken to mount it, which they have effected with the most complete success. The telescope has an aperture of 28^{cm}, a focal distance of about $3^{m}{\cdot}63$, and is provided with clockwork. It stands upon a pillar of white marble of a height of $1{\cdot}91^{m}$, under the revolving dome of the east tower. The small Equatorial has an aperture of about 13^{cm}, and is provided with two circles minutely divided, but it is without the clockwork apparatus. It also was made by Clark & Son, and is to be placed in the south tower.

In the north tower will be placed the photometer. This small, yet most beautiful, instrument is the work of Ausfeld of Gotha, in Germany, who constructed it under the immediate supervision of the inventor himself, Professor Zoellner of Leipsic. This instrument, as well as the spectroscope constructed for our observatory by Tauber of Leipsic, and which we have not yet received, is the property of the American Academy of Arts and Sciences of Boston, which has entrusted me with the sum of $500 to procure the necessary apparatus for the study of the light of the southern stars, with directions to turn over to them the apparatus acquired with this sum, or a similar amount, as may appear to be most convenient. I do not disguise the confidence which I cherish, that these instruments may be retained as the property of the National Observatory, in view of their rare beauty and excellence.

At a former time I brought it to the knowledge of your Excellency, that the great delay in the placing of the instruments and finishing the building induced me to form a plan of investigations which at the same time that it should bring into action the "personnel" of the Observatory might also conduce to useful and effective results, even without the aid of the large instruments. I informed you of the course adopted in this respect. Without loss of time there was commenced a detailed and laborious series of observations with the naked eye with the object of forming a catalogue of all the stars thus visible in the Southern heavens, according to position and degree of brilliancy and to construct thus a system of maps which shall represent the aspect of the heavens in these latitudes. Such maps do not now exist, nor have there been many accurate determinations of the quantity of light of the stars situated to the south of the Celestial Equator. My object is to supply this want, and the results so far obtained have so far exceeded my expectations that I seriously doubt if we could have done more for the progress of the science if instruments had been at our service. As far as I can estimate, two-thirds, at least, of the labor of observation and computation which this work demands is concluded—thanks to the intense application of my assistants, whose devotion in this regard is no less honorable to themselves than useful to the new institution. I hope that this work will be concluded and given to the press before the end of the current year. The results will appear in a series of charts of the heavens, as they present themselves to the naked eye, and which will comprehend the entire firmament from 10° north of the Equator to the south pole, and will be accompanied by a catalogue of the stars, arranged by constellations, which shall indicate the position and brilliancy of each one of them. This work, the first fruit of the new institution, will bear the name of "Argentine Uranometry," and no exertion on my part shall be omitted that its publication may be a stamp of honor to the nation, which with so much zeal and enlightenment is taking its first steps in the path of a higher civilization.

I have found the heavens of Cordoba less serene and more subject to clouds than I had hoped according to the received data, nevertheless when they are clear they are of an admirable transparency, as your Excellency may appreciate from the fact that we have observed and reduced to the maps about 4500 stars between the 10th degree of north declination and the south pole, while the Uranometry of Argelander, which contains all the stars visible without instruments between the north pole and 30° of south latitude, contains only 3256 stars. If the Government decides upon the publication of these results, as I cannot doubt will be the case, I am of opinion that the new process of photolithography will supply the most economical and accurate method of executing the maps—this consisting in engraving on stone by means of photographic reagents the maps drawn on a larger scale.

I trust that the completion of the *Uranometry* will occupy us only a few months more, though naturally it may be somewhat retarded by the distraction of our forces in using the instruments which are soon to come into activity. Immediately upon concluding the slow and detailed observations which the collocation of the instruments demand, I propose to commence a systematic study of the southern hemisphere, beginning at the limit to which northern astronomers have advanced. The very valuable observations taken at Cape Town, at Madras, Melbourne and Santiago will serve for a beginning to this labor, which is designed rather for the formation of a complete catalogue of all the stars within a certain limit of brilliancy, than for the attainment of the greatest possible precision in the determination of the positions of a smaller number. This work proceeds by the observation of "zones" of stars, which are intended to embrace all of a certain brilliancy, situated in a given region of the heavens. The same proceeding is successively repeated up to the definitive exploration of the entire space between the proposed limits. A similar examination has been made by the German astronomers, Bessel and Argelander, in all the heavens to the north of the 30th degree of south declination; and by the American astronomer, Gilliss, in Santiago, in Chili, in the region extending from 23°, more or less, to the vicinity of the South Pole. Though these last mentioned observations have not been published, yet they are at this moment in preparation for the press on account of the Government of the United States. If the Argentine National Observatory could coöperate by filling up the space between the two series of zones above-mentioned, so as to form a continuous whole, the scientific world would appreciate the work, and offer its tribute of gratitude through long years to come.

The National Congress has without solicitation from Dr. Gould provided for an observer's dwelling upon the Observatory grounds.

The report goes on to suggest two ways by which the Observatory can be of especial use in developing the science of the country—1st, by the telegraphic determination of longitudes; and 2d, by the formation of a system of meteorological observations throughout the Republic.

President Sarmiento and the Minister of Public Instruction have officially approved the report, and promise to put the institution into relations with the national establishments of public instruction, in order to carry on a full system of meteorological observations.

2. *Encke's Comet.*—A view of Encke's comet was obtained at the Observatory of the Sheffield Scientific School on the evening of Oct. 13th. It was barely visible as a diffuse nebula. The following places of the comet, taken from an ephemeris by S. von Glasenapp of Pulkowa, and published in No. 1854 of the *Astronomische Nachrichten*, may be of interest to observers.

0^h Berl. m. t.		A.R.			Decl.			log. dist. to ⊙	log. △	$\frac{a^2(a-1)^2}{r^2\Delta^2}$
		h	m	s	°	′	″			
Aug.	18	2	8	35·83	+23	32	33·1	0·33419	0·21013	0·53
Sept.	20	2	0	14·85	30	36	41·3	0·25522	9·97354	2·37
Oct.	21	0	21	52·73	88	54	38·5	0·14690	9·66369	17·10
	29	23	18	44·39	38	54	48·4	0·10987	9·58273	29·47
Nov.	2	22	40	41·93	37	39	10·8	0·08931	9·54811	37·06
	6	22	0	21·40	85	16	23·6	0·06716	9·52021	47·80
	10	21	19	56·91	31	44	32·8	0·04317	9·50100	58·33
	14	20	41	26·49	27	14	9·9	0·01707	9·49178	68·63
	18	20	5	57·91	22	4	26·7	9·98850	9·49254	77·96
	22	19	33	47·49	16	36	17·1	9·95703	9·50334	85·84
	26	19	4	38·22	11	6	31·3	9·92215	9·52258	92·19
	30	18	38	3·47	5	46	7·2	9·88322	9·54957	97·43
Dec.	4	18	13	41·66	+ 0	41	12·7	9·83947	9·58379	101·81
	16	17	15	19·72	−12	37	13·7	9·67272	9·72983	111·99

After reaching the perihelion December 29th, the comet will be too near the sun to be easily observed. In 1829 the comet was first seen with a light-intensity of 1·2. In 1868 it was first seen with a light of 2·2. On the night of Oct. 13th the light was about 10, according to von Glasenapp's ephemeris.

3. *Discovery of new Planet.*—Dr. LUTHER of Bilk discovered a new planet (117) on the 14th of Sept. It was equal in brilliancy to a star of the 11th magnitude.

IV. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Midway Islands, in the North Pacific.*—It is well known that the Hawaian line of islands is continued beyond Kauai in a series of coral islands or atolls, which, together with the high islands from Kauai to Hawaii, make the whole length of the Hawaian chain full 2000 miles. Some of these islands were surveyed by the U. S. Government in 1867, with reference to harbors and a place of depot for coal, to serve as a half-way station, for the North Pacific line of steamers. We take the following facts respecting the three islands particulary surveyed, from the Report to the Bureau of Navigation, in December, 1867, of Capt. Wm. Reynolds, U. S. N. These three islands are Ocean Island in latitude 28° 25′ N. and longitude 178° 25′ W; Midway or Brooks Island, in 28° 15′ N. and 177° 20′ W.; and Pearl and Hermes Island in 27° 50′ N. and 175° 50′ W.

In Brooks Island, which was the best of the three as regards harbor, the encircling reef is 18 miles in circumference. On the west-north-west side, for three miles, the reef is mostly wanting, and there are 3 to 10 fathoms water. At the northwest point there are breakers; and then from there, along by the east side, for 4½ miles, there is a steep wall of compact coral rock, of about 5 feet elevation, and only 6 to 20 feet wide, where examined; beyond this, the wall becomes a line of detached rocks, and for 2 miles is hardly above tide level, and then for another 2 miles under water, except at low tide; but for the next 4½ miles, along the southern and southwestern sides, there is again a continuous wall for 4½ miles. There is no vegetation along the wall. Whether this wall indicates an elevation of the island or not, it is difficult to say. It is more probable that there has been a subsidence of four or five feet, and that the wall is only the ruins of the coral rock that formed the dry land of an atoll once in much better condition.

The only harbor entrance is on the west or leeward side. The harbor—called Welles Harbor—is rather larger than that of Honolulu (of Oahu), and as safe, but has not quite as much water on the bar—the depth being from 21 to 16 feet at low water. The entrance between the reefs is 800 feet. On the southwest reef there is a small island, called Middle Brooks Island, whose highest point is 15 feet above the sea; its vegetation is shrubs and grasses. The lagoon is 2 miles long and 1½ miles in its greatest width. There are many clumps of coral with 1 to 2 fathoms over them; but the rest of the bottom is of white coral sand.

Turtle abound on the island, but seals were seen only occasionally. Birds were very numerous, and the young birds were so many as to make it difficult to walk any distance without trampling on them. There is but little guano, and this is probably owing to the condition of the reef.

Ocean Island is much like Brooks, in having a wall of coral rock on its northwest, north and east sides; the north side reef is at low tide level. There is no ship entrance to the lagoon. There is a green islet at the southeast corner like that of Brooks Island, its height above the sea 10 feet. The reef has a circuit of 14¾ miles.

Pearl and Hermes reef closely resembles the other two, but the wall is rather a line of detached rocks than a continuous parapet. The circumference of the reef is 42 miles, the length from east to west being 16 miles, and that from north to south 16 miles.

2. *Eruption of the Volcano of Colima in June*, 1869;* by Dr. Charles Sartorius.—To the northwest of the town of Colima rise, above lower mountains, two lofty volcanic peaks, the more easterly, capped with snow, being 3,790 metres (12,434 feet) in height, the more westerly, with a conspicuous crater, 3,580 metres (11,745 feet). The latter had an eruption in the year 1818, but has since remained in repose, though thin clouds of smoke have often ascended from its summit.

On the 12th June, 1869, a dense smoke issued from the crater, and at night a bright light was visible at its mouth; detonations like the discharge of distant artillery were heard, but no concussion of the earth took place. On the 13th there was observed from the hacienda (farm) of San Marcos, four leagues distant from the volcano, on its northeast side, at the foot of the steep cone, a glowing heaving (*Anschwellung*) of the surface, which continued to increase, and displayed intensely luminous clefts, from which were ejected smoke and red-hot stones, extending in the direction of the snowy peak above mentioned.

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* Smithsonian Report, 1869, p. 423.

The civil engineer, Ricardo Orosco, ascended the volcano on the 15th of June, accompanied by two servants and a guide. At 6 o'clock in the morning he left San Marcos, and reached at 12 o'clock a plain at the foot of the steep cone, where he left the horses. A heavy storm was prevailing, the temperature of the air being 10° Réaumur, (55° F.) On a second small plain, upon the northeast side of the mountain, was the new upheaval, which ascended to the scarp of the cone and stretched in the direction of the snowy peak, the latter being 4,500 metres (2¾ miles) distant. The upheaval in question seemed to be some 35 metres (114 feet) high and 230 metres (754 feet) broad, forming a flattened arch. The appearance was that of a wild mass of volcanic, red-hot rocks heaped one upon another and constantly in motion, not unlike freshly-burnt lime when sprinkled with water. The rocks which rolled down were, on cooling, of a gray color. A piece broken off rang like glass, and was vitreous and porous. In the middle of the upheaved mass the movement was strongest; there large clefts and intense light were displayed, while engulfed stones, which were swallowed up in great masses, were followed by a noise as of violent wind and by clouds of smoke, sometimes blue, sometimes yellow. The temperature of the air in the vicinity was 42° R., (126° F.) The stones in the midst of the heaving mass seemed to be softened, though not melted, and no flow of lava took place. Orosco ascended the cone in order to observe the phenomenon from above. This cone is very steep, and consists of sand and volcanic rubble. The temperature on the summit, which was reached at 2 o'clock p. m., was found to be 4° R., (41° F.) From hence the whole of the new upheaval could be surveyed. In the middle of it the most vehement movement was in progress, attended by the constant upheaving and descent of rocky masses, fire, and blue and yellow columns of smoke.

The upper (ancient) crater has a diameter of 150 metres (492 feet), descends in a cone-like form, and shows around its circumference many fissures and rifts. From the center and walls arose a dense sulphurous vapor. The gases from the new theater of eruption had a smell like that of burning stone-coal.

The descent was very toilsome on account of the rolling stones. At 3.30 p. m. the horses were reached, and at 9.30 the hacienda of San Marcos, where many were waiting to learn the result of the expedition. The report of Orosco was, that the district was threatened with no danger, as no lava was issuing, and the fissures being open gave no reason to fear any explosion from the tension of confined vapors. Later explorers of the volcano found a fissure from the new upheaval to the upper peak, one to three feet wide and about three feet in depth, but neither heat nor vapor issuing from it. The latest reports inform us that the same phenomena in general continue to present themselves, but that such volumes of fetid gases issue from the fissure, that the inhabitants of the district were forced to leave their abodes. Cows and sheep were killed thereby, so that it was found necessary to drive away the herds from the neighborhood of the volcano.

3. *The Variations of Gravity in the Western Provinces of Russia;* by A. Sawitsch. (Abstract, M. N. Roy. Astron. Soc., June 9.)—A great arc of the meridian having been measured in Russia with all the precision which modern methods of observation will admit of, it became an interesting subject to examine the variations of the intensity of gravity in the districts traversed by this arc, and to compare the progress of those changes with the variations which are observed in the direction of gravity determined at several stations by astronomical observations and geodetical operations. An extensive series of pendulum observations was therefore arranged by the Academy of Sciences of St. Petersburg, to be made at certain stations between Tornea in Finland, and Ismail in Moldavia, selecting only those points of which the geographical positions and elevations above the mean level of the sea were determined in connection with the great arc of meridian. The observations between Tornea and St. Petersburg were made during the summer of 1865 by M. Sawitsch and M. Lenz; those between St. Petersburg and Ismail were made in 1866 and 1868 by M. Sawitsch and M. Smyslof.

M. Sawitsch gives in detail the formulæ used by him in the reductions, and also the results of the observations, which are given for twelve different stations situated between 65° 51′ and 45° 20′ north latitude. At St. Petersburg the length of the seconds' pendulum found directly from the observations is 440·958 Paris lines, the latitude being 59° 56′ 30″.

"Our object was not so much to determine the absolute length of the pendulum as to collect new data on the variations of gravity, and to compare them with those which have been found at other stations on the terrestrial surface. We know that at London the length of the simple seconds' pendulum has been determined with great precision by Capt. Kater and by General Sir E. Sabine; and that the measures made in Great Britain by M. Biot agree perfectly with those obtained by the English savants, while those made in France by the English savants give the same results as those of M. Biot. To these determinations we may also add the observations made by travelers and naval officers in different parts of the world. To connect our experiments with the preceding system of researches, without a breaking of continuity, we prefer not to adopt our direct determination of the length of the pendulum at St. Petersburg, but rather that which was deduced from the oscillations of a similar invariable pendulum, observed by M. le Comte Luetke at St. Petersburg and at the Royal Observatory at Greenwich; the difference between the length of the seconds' pendulum at Greenwich and London having been accurately determined by Sir E. Sabine. Thus the length of the simple seconds' pendulum being known at London, we can calculate its length at St. Petersburg according to the relation of the squares of the numbers of infinitely small oscillations which the comparison pendulum, reduced to the same temperature *in vacuo*, has made at each of the stations in a mean day. In this manner, the calculation gives for the length of the simple seconds' pendulum at St. Petersburg 39·16975 English inches or 441·0319 Paris lines. Assuming this length, we have deduced, as the result of our observations, the values contained in the first three columns of the following table.

Place of observation.	Latitude N.			Longitude E. from Greenwich.			Length of the Seconds pendulum in Paris lines.	Errors. Paris lines.
	°	′	″	h	m	s		
Tornea,	65	50	43	1	36	54	441·2525	+0·0200
Nicolaistadt,	63	5	33	1	26	26	441·1293	—0·0141
St. Petersburg,	59	56	30	2	1	14	441·0319	—0·0017
Réval,	59	26	37	1	39	1	441·0190	+0·0033
Dorpat,	58	22	47	1	46	54	440·9762	—0·0002
Jacobstadt,	56	30	3	1	43	4	440·8900	—0·0157
Wilna,	54	41	2	1	41	12	440·8353	—0·0001
Bélin,	52	2	22	1	40	52	440·7268	—0·0035
Kréménetz,	50	6	8	1	42	54	440·6533	+0·0017
Kaménetz-Podolsk,	48	4	39	1	46	18	440·5844	+0·0160
Kischinef,	47	1	30	1	55	18	440·5278	+0·0030
Ismail,	45	20	34	1	55	16	440·4479	—0·0071

To examine the accuracy of each of the results M. Sawitsch has compared the length of the pendulum observed at each station, with the corresponding length obtained from the formulæ given in his paper. The residuals are as given in the fifth column of the preceding table; the sign + denoting that the observed length is greater than the calculated length.

The sum of the positive residual errors is +0·0440, and of the negative residual errors —0·0423.

Thus the formula agrees well with the equations of condition. With regard to individual errors, they depend upon errors of observation and upon anomalies in the intensities of terrestrial gravity; but it is difficult to discover in the differences given above any certain traces of those anomalies and of the local causes which produce them.

"In the work of W. Struve on the arc of meridian between the Danube and the Arctic Sea is a detailed discussion of the latitudes of the principal places between the North Cape and the Danube. The differences in latitude found directly from the astronomical observations vary only ± 1″·75 from those deduced from the geodetical operations. Athough these differences are very much larger than the errors of observation, they are not as great as those which may be found in corresponding operations in other countries. Our stations are in the neighborhood of the places discussed by M. Struve; so that it appears that in the great plains of Western Russia the directions and intensities of gravity are not subject to anomalies which change sensibly from one of our stations to another."

4. *Zoological Results of the* 1870 *Dredging Expedition of the Yacht* "*Norna*" *off the coast of Spain and Portugal;* by W. S. Kent.—A detailed list of the numerous species collected throughout the cruise being in course of preparation for the more technical and exhaustive report to be presented to the Royal Society, I here propose, commencing at the lowest animal group, to briefly enumerate some of the more important forms taken, adding such remarks on the characters or connecting circumstances which render them more especially deserving of attention. Of all, the sub-kingdom of the Protozoa has perhaps furnished us with the most abundant and valuable material, the sponge class in particular contributing many novelties. Before leaving British waters even, the few hours spent in shore-collecting at Guernsey, already alluded to, resulted in the accession of three new species of the genera *Isodictya* and *Hymeniacidon*, which I have placed at the disposal of my kind friend Dr. Bowerbank, to be described by him in his supplementary volume of the "British Spongiadæ," now closely approaching completion. The moderate depth within the Laminarian and Coralline zones, from the shore line down to fifty fathoms, at which we collected and dredged in Vigo Bay and afterward farther south in the neighbourhood of Setubal and the Sado river, proved remarkably productive of species belonging to the same group, as also to that of the Calcarea or calcareous spiculed sponges, including *Sycon* and *Grantia*, &c. The most interesting of any, however, were the species belonging to the Hexactinellidæ, or hexradiate spiculed sponges, of which the beautiful *Euplectella* and *Hyalonema* form familiar examples. Nine species belonging to this group were obtained at a depth varying from 400 to 800 fathoms off Cape Espichel and Cezimbra, including *Hyalonema*, *Dactylocalyx*, *Aphrocallistes Bocagii*, *Lanuginella pupa*, and four other species new to science, three out of which necessarily constitute the types of new genera, the residue again furnishing data enabling us better to appreciate the characters and distinctions of those previously made known to us. The form belonging to the same group, and described by myself as *Pheronema Grayi*, and exhibited at the last meeting of this Association, is the most conspicuous among all these on account of its size, and I would here add a few more words in reference to this particular type. Since last year I have been afforded the opportunity of examining and comparing my own with numerous specimens of Prof. Wyville Thomson's *Holtenia Carpenteri* taken in the North Sea and also in the Atlantic, and from an evolutionist's point of view, this examination has led me to regard my specimens as holding rather the rank of a well-marked local variety than of a distinct species as I at first premised. A comparison of the specimens, now placed side by side in the British Museum collection, will, I think, suffice to prove to all those interested in this subject how strongly marked as varieties these two forms are. Meanwhile, the generic name of *Pheronema*, adopted by myself, I still retain, as I consider both Prof. Wyville Thompson's form and my own to be local varieties of another species

first described by Dr. Leidy of Philadelphia as *Pheronema annæ,* and a letter recently received from Dr. Leidy himself more fully convinces me of this, though he has not yet bestowed on it the minute microscopical investigation of its structure needed for the effectual clearing up of this, at present, doubtful point.

In my description of other sponges belonging to this same Hexactinellate group, read before the Royal Microscopical Society, and published in their "Transactions" for November, 1870, I have, in creating a new genus and species, *Askonema Setubalense,* erroneously associated Prof. Thompson's name with it as having once pronounced the form to be of vegetable and not animal organization. The mistake arose from the misconception of a name singularly similar in euphony as pronounced to me by Prof. du Bocage, and I here avail myself of the opportunity of rendering Prof. Wyville Thompson that *amende honorable* I feel myself in duty bound to accord to him.

Passing next to the class of the Foraminifera, our gatherings have been remarkably rich both from the coralline and abyssal zones, the latter furnishing us with numerous arenaceous types (*Rhabdomina*, &c.), and the former being notably abundant in species and varieties of *Lagena* and *Cristellaria.* Many of these forms are new to science and await description.

The Cœlenterate sub-kingdom has likewise furnished several new and rare forms, including among the latter category an example of *Hyalopathes pyramidalis,* M. Edw., one of the Antipathiidæ now represented for the first time in our national collection, if not in this country. In the Alcyonarian group, *Veretillum cynomorium,* first taken sparingly in Vigo Bay, and afterward abundantly in the Laminarian zone near Setubal, excited our warmest admiration.

Nothing can exceed the beauty of the elegant opaline polyps of this zoophyte when fully expanded, and clustered like flowers on their orange-colored stalk; a beauty, however, almost equalled by night when, on the slightest irritation, the whole colony glows from one extremity to the other with undulating waves of pale green phosphoric light. A large bucketful of these Alcyonaria was experimentally stirred up one dark evening, and the brilliant luminosity evolved produced a spectacle too brilliant for words to describe. The supporting stem appeared always to be the chief seat of these phosphorescent properties, and from thence the scintillations traveled onwards to the bodies of the polyps themselves. Some of the specimens of this magnificent zoophyte measured as much as ten inches from the proximal to the distal extremity of the supporting stalk, while the individual polyps, when fully exserted, protruded upwards of an inch-and-a-half from this inflated stalk, and measured as much as an inch in the diameter of their expanded tentacular discs.

Numerous Polyzoa were also dredged up from the various depths, many of which remain yet to be identified; but the allied group of the Tunicata has perhaps furnished by far the most interesting material of the whole molluscoidan sub-kingdom; surface-skimmings one morning near the mouth of the Sado river having rewarded us with numerous specimens of an *Appendicularia*, which, from notes and sketches made at the time of their capture, I have since found to have presented phenomena seemingly not yet observed by any other naturalist. Hitherto these organisms have been presumed to constitute a distinct genus of Tunicata *inter se*, or otherwise to be the larval conditions of higher forms. My own observations, however, recorded in the last July number of the "Quarterly Journal of Microscopical Science," have led me to believe that they are the free swimming reproductive zooids of higher Tunicates, bearing the same relation to them as many free swimming *Medusæ* do to some stationary hydroid colony. At the greater depth of 600 and 800 fathoms, various species of *Terebratulæ* were taken as representative of the class Brachiopoda.

Ascending yet higher to the sub-kingdom of the Mollusca, a large variety of interesting species rewarded our researches. Included among these were—*Fusus contrarius*, a common fossil of the Norfolk crag recently discovered in the living state in Vigo Bay by Mr. McAndrew, and dredged by us in the same locality; also a species of *Cassis*, remarkable from its being more closely allied to *C. Saburon* and other species inhabiting the Japanese and Chinese seas than to any of its Mediterranean or Atlantic congeners. This circumstance of its affinity is the more remarkable when associated with the occurrence of a species of *Hyalonema* (*H. lusitanica*) off the same coast, likewise scarcely distinguishable from the more familiar Japanese form *H. Sieboldi*.—*Nature*, *Oct.* 5.

5. *Destruction of the Museum of the Chicago Academy of Sciences.*—Among the devastations of the great Chicago fire, not the least in importance was the burning of the Museum of the Chicago Academy of Sciences. The building was supposed to be fire-proof, but a letter to Professor Agassiz from Dr. Wm. Stimpson, the Curator, says, "it collapsed like a bubble in the intense heat, as did indeed all other 'fire-proof' buildings in the city." The Museum contained the largest collection of Crustacea in the world, "filling," as the same letter says, "more than ten thousand jars," included the very extensive suite of specimens and species, even to the types of all the many new species, gathered by Prof. J. D. Dana in the Wilkes Exploring Expedition in the Atlantic and Pacific Oceans, the basis of his Report of 1,500 pages in 1855 on that subject; and also the large collections made by Dr. Stimpson himself in his cruise in the Ringgold Expedition to the North Pacific, besides his recent collections from the Gulf of Mexico, and specimens from various other sources. There were also the alcoholic specimens of other invertebrata, obtained by the Wilkes Exploring Expedition, and those of Dr. Stimpson's own Pacific and Gulf collection. There were also in the Museum, unfortunately, the Crustacea dredged up by Mr. de Pourtales in his late dredging expeditions, these having been sent there for description and a final report.

Dr. Stimpson writes, that besides his private collections, all his books and his manuscripts, the result of twenty years of labor, are gone. He says, "Everything of value that I had in the world was deposited in the building for safety, and I am now left utterly destitute." Dr. Stimpson had published only brief descriptions of the species collected by him in the North Pacific expedition, and had been engaged during the past two years, along with an artist, in preparing for the press a full report, with detailed illustrations of all the species. These are among the lost.

Dr. Stimpson is one of the ablest and most energetic workers in zoology in the country; and he deserves something more than ordinary commiseration. Should a scientific library be restored to him by gifts from others over the world, and from owners of duplicate copies of zoological works, it would not be more than a just return for all his unwearied labor in the cause of science.

6. *Earthquake in New Jersey, Delaware, and Pennsylvania;* by W. C. TAYLOR. (From a letter to Prof. Newton, dated Haddonfield, N. J., Oct. 10, 1871.)—The earthquake which was felt in Delaware yesterday was very distinctly observed in this place. The time noted by one of our school teachers here, an exact observer, was 20′ before 10 A. M., the same as that stated by the Wilmington writers.

The noise heard in Haddonfield was similarly described by all observers as resembling the dragging of heavy furniture over the upper floors of the houses, or the rumbling of heavily-laden wagons along the streets. It was sufficiently startling to bring some persons to their doors, to look for the cause of the disturbance.

In a subsequent letter, Mr. Taylor states that the shock was felt also in Philadelphia, at the same time, 20′ before 10. The shock was felt at Dupont's powder mills, where there was not an explosion, as has been suggested.

OBITUARY.

PETER D. KNIESKERN, M. D., died at Shark River, New Jersey, on the 12th of September last. He was born at Berne, Albany county, N. Y., June 11, 1798. When a boy his love of nature and of books was such that his father despaired of making a farmer of him, and he consequently, but with great difficulties, found his way to a liberal education. He took his medical degree about the year 1829 or 1830, at Fairfield (College of Physicians and Surgeons of the Western District,) N. Y., then a famous school of medicine. He early became passionately fond of Botany, was an indefatigable collector and a keen observer. Few botanists have excelled him in their knowledge of the plants of the region in which he resided, and none in zeal, simplicity and love of science for its own sake. Neither poverty nor want of opportunity and companionship appear to have discouraged him, although they restricted his researches to a comparatively narrow field. He first established himself, as a physician, at New London, then removed to Oriskany, N. Y. He published in the Report of the Regents of the University for 1842, a catalogue of plants of

Oneida county, of which Dr. Torrey took occasion to speak in the highest terms, while also acknowledging the most efficient aid which Dr. Knieskern had rendered him in the preparation of his Flora of the State of New York. In the year 1841, upon Dr. Torrey's recommendation, he removed to a new field, which seemed to offer an opening for a medical man, while it afforded a richer harvest of rare plants than any other district in the Northern Atlantic States, viz: the Pine barrens of New Jersey. He lived first at Manchester, Ocean county; six years later he removed to Squam Village, Monmouth county, and six years afterwards to Shark River, where he remained to the end. Over this whole prolific and peculiar pine-barren region he botanised with utmost assiduity and skill, and amassed a large number of specimens, which, as age advanced have accumulated on his hands, and which, it is hoped, may be disposed of for the benefit of his family. It should be especially rich in Carices, to which he devoted much attention; and several most interesting species are almost peculiar to that district or even to some few localities in it. The character of that flora may be gathered from the catalogue of the plants of parts of Ocean and Monmouth counties, New Jersey, which Dr. Knieskern published, and from a greatly extended edition of it which subsequently appeared as a contribution to the Geological Survey of the State. What particular course will be adopted in reference to these botanical *reliquiæ*, the writer of this notice is at present unable to say. But those wishing for information may address communications to him, or, which is better, to the Rev. Samuel Lockwood, Freehold, New Jersey, to whom we are indebted for the facts relative to Dr. Knieskern's later life. He informs us that his lamented friend died of paralysis, in his 74th year, with unclouded intellect, the same simple-hearted, truly but most unpretendingly good and faithful man that he had always been. At least two species of his own discovery bear his name, and both are of the Sedge Family, in which he especially delighted. These, and the repeated mention of his discoveries in various works will keep his memory green and name perennial in American Botany long after the few surviving companions of his youth have passed like him to another world. A. G.

John Edwards Holbrook, of South Carolina, died at Norfolk, Massachusetts, on the 8th of September. He was born at Beaufort, S. C., in 1794, and graduated at Brown University; and since 1824 has occupied the position of Professor of Anatomy in the State University of South Carolina. He is chiefly known from the extent and magnificence of his works upon the reptiles of North America, and upon the fishes of South Carolina. Of these the first-mentioned appeared in its completed form in 1842, occupying five quarto volumes, and giving figures and descriptions of all the species of reptiles then known in the United States—about one hundred and sixty in number. Some volumes had been previously published and canceled by the author in consequence of their supposed imperfection. The advance in our knowledge of American reptiles since that time may be learned from the fact that we are at present acquainted with not far from five hundred species.

The work on the fishes of South Carolina was equally difficult to bring to a conclusion satisfactory to its author, several numbers having been canceled and replaced. The publication, indeed, was never entirely finished, the commencement of the civil war having interfered with its completion, although, as it stands, it embraces the only available series of illustrations of the greater part of the Southern species. It is said that a eulogium upon Dr. Holbrook is to be delivered before the Boston Society of Natural History by Professor Agassiz at some future day.—*Harper's Weekly.*

James De Carle Sowerby, died August 20th, at the age of 84. Mr. Sowerby was well known as a naturalist; still better, however, as an artist, his illustrations of shells, plants, and other objects of natural history being considered of superior excellence, and gracing the pages of many of the more important works of natural history published in England for many years past. It was in the branches of conchology and botany that he was most prominent; in the latter department, mainly in connection with what is known as "Sowerby's English Botany," intended to give a life-size colored figure of every British plant; and of which eighty-one fasciculi, or ten volumes, are already published at a cost of over $10,000 per set.—*Athenæum.*

Sir Roderick Impey Murchison, the eminent geologist, died in London on the 23d of October, aged 79, having been born in 1792.

V. Miscellaneous Bibliography.

1. *The Linn-Base decimal system of Weights, Measures and Money;* by W. Wilberforce Mann. New York, 1871. pp. 20.—This system is based upon the following, as principal units: the *linn*=1 dekameter; the *arr*=1 sq. dekameter; the *soll*=1 *capp* =1 liter; the *pondd*=1 kilogram, and the *monn*=5 francs. The multiples ascend by tens by the Greek prefixes, Hena-, Dua-, Tria-, Tetra-, &c., and the parts descending by tens are denoted by Latin prefixes, Primi-, Bini-, Tern-, &c.

2. *Earthquakes, Volcanoes and Mountain building;* by J. D. Whitney. 108 pp. 8vo.—Three articles published in the North American Review. A valuable and interesting discussion of many of the views connected with the three subjects mentioned in the title, with the results of the author's own important investigations.

3. *The Minerals and Geology of Central Canada: a hand-book for practical use;* by E. J. Chapman, Prof. in University College, Toronto, and Consulting Mining Engineer.—This is a second and enlarged edition of Professor Chapman's Hand-book. It contains the only systematic account of Canadian Mineralogy, and a brief sketch of its Geology.

Three and four place tables of Logarithmic and Trigonometric Functions. By Prof. J. M. Pierce, of Harvard University. Ginn Brothers, Boston. pp. 16.

Elements of Trigonometry. By Prof. E. Olney, of the University of Michigan, Shelton & Co., N. Y.

General Geometry and Calculus. By the same author and publishers.

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ART. XLIX.—*On the Geological History of the Gulf of Mexico*; by E. W. HILGARD, of the University of Mississippi.* With a Map.

THE colored outline map before you, without much pretension to accuracy of detail, shows the general geological features of the great embayment, once a portion of the Gulf of Mexico, whose axis is now marked by the course of the Mississippi river, from southern Illinois to its mouth. I have compiled this map from the best data now extant, accessible to me, with a view to the better elucidation of the succession and character of geological events; and especially with a hope of bringing to bear upon the later formations of the interior of the continent, the chronological record here left by the retiring waters of the sea. Marine deposits being better understood and more available for general comparison and conclusions than those of inland lakes, the series here shown would seem, by its original connection with the interior basins, to promise a key to the determination of equivalence in time, that, in view of the violent disturbances in the Rocky Mountain region, it might be difficult to find in that portion of the continent.

The subject matter of the present communication is, for the greater part, embraced in publications made by myself during the past ten years; and to these publications I must refer for the corroborative detail, which in this general summary would be out of place.

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* Read before the American Association for the Advancement of Science, at Indianapolis, August, 1871.

Cretaceous period.

The most ancient shore-line of the Mississippi embayment is formed mainly by the various stages of the Carboniferous rocks. It is only in eastern Alabama and the adjoining portion of Georgia, that the Silurian and metamorphic rocks formed the shore of the Cretaceous seas. The deposits of the latter period have been traced by Safford up to the Kentucky line, along the western foot of the paleozoic ridge which compels the Tennessee river to make its long détour northward; and the Cretaceous outcrop doubtless extends, in a northwesterly direction, some distance into Kentucky.

In the portion of this belt embraced within the States of Mississippi and Alabama, the dip is sensibly at right angles to the trend (i. e., between W. and S.) at the rate of twenty to twenty-five feet per mile. In its southerly portion especially, the Cretaceous beds are very distinctly divided into three principal stages, viz:

1. A lower one 300 to 400 feet thick—*Coffee group* of Safford (Eutaw group *mihi*)—consisting of non-calcareous sands, and blue or reddish laminated clays, with occasional beds of lignite, and but very rarely (Finch's Ferry in Alabama) marine fossils, silicified; corresponds doubtless to Hayden's Dakota group, including, perhaps, in its upper part the equivalents of the Fort Benton group, to whose fossils those of Finch's Ferry, collected by Tuomey, bear a close analogy.

2. The middle or Rotten limestone group, not less then 1,200 feet in maximum thickness. Soft, mostly somewhat clayey, whitish, micro-crystalline limestones and calcareous clays; very uniform on the whole, if we except the locally important, but not generally extant, feature of the "Tombigby Sand," the special home of Inocerami, Selachians, and gigantic Ammonites.

3. Ripley group: crystalline, sandy limestones, alternating with dark colored glauconitic marls containing finely preserved fossils. Thickness 300 to 350 feet. Equivalent of the highest bed of the Cretaceous of New Jersey, and doubtless of Hayden's Fox Hills beds.

How far the Rotten limestone, as a whole, may be considered as embracing the whole of the series intervening between Hayden's Fox Hills beds and Dakota group, remains to be shown. The fauna of the Tombigby sand sub-group is distinguished, as already stated, by the great number, both of individuals and species of Inocerami, and of remains of (chiefly Selachian) fishes, wherein it corresponds to Hayden's Niobrara division; its fossils have been partly named and described (somewhat imperfectly) by Tuomey.* According to Hayden's view of the New Jersey

* Proceed. Philad. Acad.

equivalents, the Rotten limestone would be represented by his Fort Pierre group.

The distinctive features of these several groups become less marked the farther we advance northward, even in Mississippi. Non-fossiliferous or lignitic clays and sands mingle with the marine strata; and become altogether predominant, it would seem, near the northern termination of the outcrop.*

West of the Mississippi, the continuous Cretaceous outcrop does not extend as far northward as on the east side, by some 150 miles. Nor have the more ancient lignitiferous beds (Coffee group) been observed there, with certainty, within the limits of this map. The Cretaceous area of Arkansas, according to Owen's description, falls almost altogether within the limits of the Rotten limestone group; and the same seems to be true of the greater part of the Cretaceous area of northern and middle Texas. Nevertheless, the series of isolated Cretaceous outliers, which traverses Louisiana from the head of Lake Bisteneau in a S.S.E. direction, terminating probably in the great rock-salt mass of Petite Anse†, exhibit the main characteristics of the Ripley group; while deep borings have demonstrated the presence, for a thousand feet beneath, of the uniform Rotten limestone, such as it exists on the prairies of Mississippi and Alabama. I have elsewhere‡ stated the stratigraphical as well as lithological reasons which induce me to consider both the rock-salt of Petite Anse, and the sulphur and gypsum deposits of Calcasieu, as lying within the limits of the Cretaceous formations.

The data given by D. D. Owen seem to assign to the Cretaceous strata of Arkansas a dip S. or slightly W. of S. The outliers in Louisiana are too limited in extent for determinations of dip; but it can scarcely be doubted that they represent the summits of a (more or less interrupted) ancient ridge, a kind of "backbone" to the State of Louisiana, whose resistence to denudation has measurably influenced the nature and conformation of subsequent deposits. It is fair to presume that from this ridge the strata dip toward the axis of the Mississippi Valley, to meet those on the opposite side; and the depth at which these beds are found in the Calcasieu bores, seems to indicate, on the western slope, a south-southwesterly dip of three to four feet per mile. A glance at the map shows, nevertheless, that the general form of the northern Gulf shore was not materially influenced by the existence of this axis of elevation, which probably was marked merely by a series of disconnected islands in the early Tertiary sea that, after the emergence of the immence Cretaceous area, already prefigured the present Gulf of Mexico.

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* Fide Safford.

† Indicated on the map by the localities of Petite Anse, Chicot, Winfield and Bisteneau.

‡ This Journal, Nov., 1869, p. 345.

It would be bootless to speculate, at this early moment, on the precise origin of the great rock-salt, gypsum and sulphur deposits. That the prominent event of the epoch—the emergence of an extensive sea-bottom—afforded abundant opportunity for the accumulation of the two former substances, is obvious enough; it would seem to pre-suppose, however, a temporary or partial isolation at least from the general ocean, analogous to that which, apparently, occurred in later times. But as regards the sulphur, its ordinary co-occurrence with gypsum would hardly seem to afford a sufficient precedent for the present case; unless we assume the concurrent influence of volcanic or other "abysso-dynamic" agencies.

Tertiary period.

It will be perceived that during the Tertiary period, the northern Gulf shore receded from its extreme northern limits in southern Illinois and Missouri, to a shore-line which, though running near the latitude of Bâton Rouge, is not far from parallel to the present one, if we ignore the extreme projection of the Mississippi delta. This rapid filling-in of the embayment, no less than the character of the deposits, prove that the depth of water was not great; especially in the remoter portions, where lignitic and lignito-gypseous deposits very sparingly interspersed with small marine beds (the remnants of estuaries) from the predominant material. Similar alternations of materials occur, in fact, throughout the older Tertiary deposits of the southwest; and hence, the divisions marked off by difference of color on the map, as "lignitic" and "marine" Tertiary, respectively, must be taken very much *cum grano salis.* Except only in southern Arkansas, few marine beds of any notable extent occur outside (i. e., north of) the limit of the area indicated as marine. But in northern Louisiana, where the dip is very slight, lignitiferous strata are altogether predominant on the surface; although the marine seem to underlie everywhere at no great depth, and in numerous localities crop out on the surface; forming, according to Hopkins, distinct beaches around some of the Cretaceous outliers mentioned above.

So far, indeed, from considering the predominantly lignitiferous area as representing a period distinct from the older marine Tertiary, I have little doubt that the larger portion, if not all, of the beds I have heretofore designated as the Northern Lignitic (and Flatwoods clay) group (Lagrange and Porter's Creek groups of Safford) are the strict equivalents in time of the oldest marine beds observed in South Carolina and Alabama, and designated by Tuomey as the Buhrstone group ("Siliceous Claiborne" of my Miss. Report). The lithological continuity of the bed-rocks of this group along the eastern border of the Tertiary, supported to some extent by paleontological evidence, strongly inclined me to this opinion ten years ago;* and it has received a strong confirmation from the latest observations of Dr. E. A. Smith, of the Miss. Geol. Survey, who has found the same rocks, substantially, continuous along the southern border of the lignitic area, nearly to the Mississippi bluff. At the same time, Safford mentions the occurrence of similar beds on the border of the Cretaceous, in Tennessee. The inference is inevitable that no beds outcropping in the fork of these two marine branches can be anterior in time; the interconnection, in fact, is such as to render the supposition that there can be any material difference of age almost stratigraphically impossible. The exclusively lignitic character of the central portion must, therefore, be ascribed rather to the inaccessibility of that region to the waters of the sea during their deposition; perhaps in consequence of a change of level, by which the upper portion of the embayment, from about the mouth of the Arkansas to Cairo, was converted, for the time being, into a littoral marsh.

In Arkansas, nevertheless, small marine beds are more liberally interspersed among the lignitic clays, than is the case east of the Mississippi; and some of those mentioned by Owen as occurring on the territory here laid down as chiefly lignitic, are obviously more closely related to the celebrated Claiborne shell-bed than to the Buhrstone group. The latter group does not, in fact, appear characteristically developed anywhere west of the river, so far as I know; and the occurrence of somewhat extensive marine Tertiary outliers on the Cretaceous territory of Arkansas, as well as of lignitic beds on that of Texas (e. g., the Cross Timbers, as approximately laid down on the map), proves that although the deeper water of the embayment followed substantially the lines of trend shown on the map, yet there still existed at that time a connection, in a northwesterly direction, of the Gulf waters with those of the great interior basin of the West.

That this connection should not be uninterruptedly traceable at the present time, is not surprising when we consider the shallowness of the connecting trough, as demonstrated by the inconsiderable thickness of the deposits, that of course greatly favored their removal by the subsequent events of the Quaternary period. Nevertheless, enough seems to remain of these deposits to form a chain by which, with the aid of paleobotany, the equivalents in time of the Buhrstone and Claiborne marine groups, at least, can be determined among the fresh or brackish-water beds of the interior. And with these as fixed horizons to start from, aided also by the flora of the subordinate lignite beds of the later (Jackson and Vicksburg) stages, we may hope to establish a comparative chronological scale through which the parallelisms with more distant regions, and later times, may be established even for the much-discussed Tertiary beds of the Great West.

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* Miss. Rep., 1860, §§ 162 and ff. 188, etc.

My present purpose scarcely requires that I should more than allude to the detail of the later stages of the older Tertiary, which I have not distinguished on the general map, in order not to obscure too much the general features. But a detailed map shows both the successive decrease in the width of their outcrops, and the regularly diminishing convexity of the Gulf-outline. I may also add that as we recede from the vertex of the embayment, and eastward from its axis, there is a regular increase of deep-sea features, the lignitic facies becoming more and more subordinate; yet, by its persistent recurrence seeming to intimate the occurrence, if not of oscillations, at least of local variations of depth; dependent, perhaps, upon corresponding changes in river mouths. In Alabama, the lignitic feature is almost suppressed, the marine stages overlying each other directly, as a rule; while west of the Mississippi, it becomes more and more pronounced as we advance westward, so that all but the latest portion of the Jackson, and most of the (much diminished) Vicksburg sea, here represented, appears to have been an intricate maze of everglades and shallow estuaries. That this state of things is intimately connected with the existence of the Cretaceous "backbone" of Louisiana on one hand, and the decided southward dip of the same formation in Alabama on the other, can scarcely be doubted. At the same time, let it be remembered that both east and west of the Mississippi, from the Chattahoochee to the Sabine, the older Tertiary period closes with a decided prevalence, in the Vicksburg limestones, of the deep-sea character; and thus far, the geological history of the gulf does not exhibit any phenomena whose parallel may not, *mutatis mutandis*, be found on the coast of the Carolinas. Moreover, the transition from the oldest to the more modern (Vicksburg) fauna is so gradual, gaps existing in Alabama and Mississippi being completely filled by transition strata observed by Hopkins and myself in Louisiana, that any attempt at subdivision into eocene and "oligocene" must draw altogether artificial lines of demarcation.

But while on the Atlantic coast we meet, in the Miocene and Pliocene strata of Maryland, Virginia and the Carolinas, a gradual approximation to, and admixture of, modern marine forms, the Vicksburg epoch closes abruptly, so far as the Gulf of Mexico is concerned, the marine Tertiary series. The geologically as well as agriculturally barren rocks of the *Grand Gulf* age lack all analogy outside of the Gulf basin, unless it be those of the Bad Lands of Nebraska, and especially the White River beds, to which they bear an extraordinary lithological (as well as in some respects, stratigraphical) resemblance. However little this circumstance may prove as regards equivalence in time, we must, nevertheless, not forget that, as the only representative of the geological period intervening between the eocene and the Drift on the Gulf shores, the Grand Gulf group almost necessarily embraces among its equivalents these very beds; and since Marsh has found the latter so much farther south than they were supposed to exist but a short time ago, it is not altogether impossible that more direct relations between the two may yet be proven. The Grand Gulf rocks form the highest ridges of Louisiana as well as of south Mississippi, falling off rather abruptly into the level prairie country of the marine Tertiary. But even these ridges are capped by the ferruginous sandstone of the southern drift, which may have been instrumental not only in greatly diminishing their height, but also in sweeping away the links connecting them with the interior; as has unquestionably happened with regard to the older Tertiary.

Be that as it may, whether actual connection existed or not, we cannot escape the conclusion that analogous circumstances were required to produce analogous deposits. Foremost among these was *the exclusion of the sea;* nor can we account for the extreme scarcity of both animal and vegetable remains, that scarcely leaves us a hope of direct identification, unless upon the supposition that the water which deposited these beds was, take it altogether, too fresh for a salt-water fauna, yet too salt to admit of a fresh-water population. The solitary fragment of a turtle, recognized by Prof. Marsh, is all that has so far rewarded my many years' search for zoögene fossils in this formation; and with the exception of a single locality in Mississippi, not yet fully explored, the prospect for recognizable fossil plants is about equally discouraging.

I confess that such absolute dearth of life rather staggers my belief; and my later observations on the deposits of the Port Hudson (Quaternary) beds have led me to conclude, that in some degree this absence of life is only apparent; and that the *calcareous concretions*, so abundant in some of the clay strata of the formation, are but the substance of perhaps a very diversified fauna, whose calcareous portions have been thus transformed by maceration.* The calcareous ingredient, however, occurs only in the lower, clayey division of the series; and it is sufficiently remarkable that the fine sand- and clay-stones of the upper division should have preserved no vestiges of eith animal or vegetable life.

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* This Jour., Jan., 1869, p. 81; Ibid., Nov., 1869, p. 338.

I do not see how, in view of the nature, thickness (about 25 feet) and wide distribution of this formation, the inference ca be avoided that during the whole or a part of the interval between the Vicksburg and Drift ages, the Mexican Gulf was, by some means, isolated from the Atlantic ocean; or that at leas its communication, perhaps across the still submerged peninsula of Florida, was so imperfect as to render the influx from the interior of the continent predominant over the original supply of sea-water. An upheaval of the northern borders of the Caribbean basin could easily accomplish this result, so long as the deep channels excavated by the Gulf stream in the strait of Yucatan, as well as those of Florida, did not yet exist. Too little is as yet known with accuracy regarding the geology of the nearer Antilles and Yucatan, to determine whether they bear the marks of the event recorded by the Grand Gulf rocks on the northern shore of the basin. The observations of Mr. Gabb in Sto. Domingo, and of the English geologists in Jamaica, seem to indicate the existence there of marine Miocene and Pliocene tertiaries, which are altogether unrepresented in the waters of the Gulf. It has been suggested to me that beds of that character may be covered by the Grand Gulf and later beds of the Gulf coast. I willingly leave the onus of proof on that score to those who may think such an assumption desirable. But were this the case, the necessity for assuming the cutting off of the Gulf basin from the Atlantic, on account of the existence of the Grand Gulf rocks, would be none the less cogent; for I doubt whether any geologist, upon full consideration of the facts, would for a moment entertain the idea that like the "Northern Lignitic" of the older Tertiary, the Grand Gulf beds could be explained away as a mere littoral formation.

It is worthy of remark that while east of the Mississippi, the peculiar sand- and clay-stones of this group are confined to the northwesterly portion of its area of occurrence, in Louisiana and eastern Texas these rocks are altogether predominant, especially along the northern (or landward) border, the clays being subordinate.

Quaternary beds.

The Grand Gulf rocks are almost everywhere immediately overlaid by the deposits of the stratified Drift or Orange Sand. Of course it overlies equally, as a rule, the more ancient formations (except where, from causes not always readily imagined, it seems to have been subsequently removed) up to the limits of the Paleozoic. Beyond these, its occurrence is more or less localized in conformity with the larger valleys, as observed by afford in Middle and Eastern Tennessee, and by Tuomey and yself in Alabama. The same is true, apparently of the larger annels of Texas. But within the limits of the Mississippi mbayment, it constitutes one huge delta-shaped mass, covering e entire Tertiary, and a large portion of the Cretaceous area, a depth varying from a few feet to over two hundred; on an verage, perhaps, between sixty and one hundred feet. Its preominant material is orange or reddish, rounded sand, mostly erruginous, of various degrees of induration, with subordinate eds of clay, and enormous gravel-streams, evidently denoting ncient channels.* Its beds disappear beneath those of the ort Hudson age about concurrently with those of the Grand ulf era; and consequently, it cannot well be independently epresented on the map.

I have heretofore† shown that in order to explain the phenonena offered by the Orange Sand of Mississippi and Louisiana, it eems necessary to assume that prior to its deposition, the Gulf oast suffered an elevation to the extent of at least 450 feet above ts present level, accompanied by a much greater uprising near the ead of the waters. This elevation was succeeded, during the "Champlain" epoch, by a slow depression to at least twice that amount; and finally, during the Terrace epoch, a re-elevation to at least the extent of 450 feet took place. These figures are *minima*, if we regard the sea- or rather the Gulf-level to have remained constant. But if, as seems necessary to assume, the Gulf was an isolated basin during the Grand Gulf era, it might possibly have been elevated as a whole, and the zero-point of the scale would be changed upward, accordingly. The same, in a reverse direction, would be true if it could be assumed that the occurrence of the glacial epoch sensibly affected the general level of the ocean.

Be that as it may, the gravel is composed of northern rocks, disposed in belts, of which one occupies the main axis of the embayment, while others mark outlets now closed; and the extensive denudation and violent plowing-up of the more ancient formations, clearly proves the occurrence of an immense flow of waters southward, which in the main channels moved pebbles of many pounds weight; while between these, the deposition of the finer materials took place in more quiet waters.

That these events were not of a local character; that on the contrary, the phenomena observed in the Southern States are but the necessary consequence and complement of the Drift phenomena at the North, hardly requires discussion; but it is time that these facts were more generally understood and taken into account by American geologists, and that the Ohio should

* Miss. Rep., 1860, this Jour., May, 1866, and other papers above referred to.

† This Jour., Nov., 1869, p. 335.

cease to be proclaimed the southern limit of the "Drift." A kind of settled prejudice on this point seems to have obscured the vision of more than one observer, in consequence whereof these deposits have been claimed, over and again, as portions of every formation existing in the southwest, from the Carboniferous to the Bluff or Loess. Thus, in northeastern Texas, they have been accounted of Tertiary age; the "Tertiary iron ores" of that region being precisely the same as those of the "Orange Sand" of Louisiana and Mississippi. The same is doubtless true, according to Safford, of the "Iron ore banks" of Tennessee, associated with the "Ore region gravel," precisely as is the case in northeast Mississippi. In Arkansas, Crowley's ridge, a peculiarly characteristic Orange Sand ridge abutting on the Mississippi river at Helena, has been properly accounted of Quaternary age by D. D. Owen; but he associates with it the underlying lignitic beds, which it is impossible to distinguish from those cropping out directly opposite, on the Mississippi river bluff, in Mississippi and Tennessee; and which are directly traceable to their connection with the oldest Tertiary.

Tuomey first asserted the existence of this southern Drift from Alabama to South Carolina, and conjectured its equivalence to the beds which underlie the cities of Richmond, Washington and Baltimore. I ascertained its wide prevalence in the States of Mississippi, Louisiana and Texas, and identified with it the superficial beds observed by Owen in Arkansas and southwestern Kentucky, and by Safford in Tennessee. So close and cogent a connection was thus established between it and the "modified Drift" of the Northwest, that I can no longer doubt its equivalence, whatever may be the precise mode of origin assigned to it. The "Eastern gravel" streams observed by Safford in the mountains of Tennessee, and no less by Kerr in North Carolina, have their counterparts in the rivers of Texas, and in the great pebble-belts of the Mississippi embayment.

But it will be difficult to combine into a harmonious whole the widely differing observations and opinions of geologists on the vexed Drift question, unless some agreement is come to as to the precise meaning of the word. Let it be understood that the term Drift, *unqualified*, shall embrace all the deposits formed between the end of the Tertiary period and the beginning of the Champlain era of depression, when "drifting" ceased on this continent, outside of river channels, and that within this *Drift period* are embraced, whether as consecutive, or more or less simultaneous, but genetically distinct formations, the Glacier-drift or moraines; the Iceberg (or "glacial") drift of the Northwest; and finally the "modified," or rather, *stratified* Drift* of the Western, South Atlantic and Gulf States. It will then become possible, by a comparison of the really cognate phenomena, to trace more definitely the history, both general and local, of that turbulent period, without the confusion attending the use of a word to which each observer attaches, more or less, a different meaning.

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* The name "modified Drift" would be altogether inapplicable to a large part of the southern Drift, which is to a large extent "modified" Cretaceous and Tertiary material, only re-stratified, Drift-fashion.

If it be fully ascertained that in its lower course the Ohio is (sensibly) the extreme southern limit of the "glacial" Drift, while the stratified Drift is substantially continuous from the lakes to the Gulf shore, we have before us a definite problem as to the causes, that can probably be solved by a close examination of the critical region, viz: the southern border of the Paleozoic in the Mississippi Valley. The general relations of the Drift to the Allegheny range are thus far, unfortunately, involved in great obscurity; yet a knowledge of these, especially on the western slope, seems almost a necessary condition precedent of any probable hypothesis regarding the history of the Drift period West and South. It is only thus that the possible existence of an ancient barrier across the Mississippi Valley, at the head of the embayment, may be either established or disproven.

The next formation laid down on the map is the Port Hudson group, of which, however, the outcropping *littoral* portion only is here represented. Properly speaking, it should be shown as occupying also most of the space colored as alluvial, since it underlies everywhere, not only the marine alluvium (and a portion of the Gulf itself), but also that of the Mississippi and its chief tributaries, at least as high up as Memphis, and on Red river, nearly if not quite up to Shreveport. It seems to exist equally in the valleys of other larger rivers tributary to the Gulf; notably in that of the Pascagoula, up to one hundred miles (in a direct line) from the coast.*

Having discussed this formation somewhat in detail in papers recently published, I will merely state that it embraces a group of partly littoral and estuarian, partly swamp, lagoon and fluviatile deposits, whose thickness and location is manifestly dependent upon the topographical features of the continent, then (during the "Champlain" period) in progress of slow depression; as shown by the nature of the deposits, and the numerous superimposed generations of large cypress stumps, imbedded in laminated clays exhibiting the yearly fall of leaves. These beds overlie those of the Orange Sand or Stratified Drift, while themselves overlaid by, not only the river alluvium, but also by the Loess or Bluff silt or its equivalents; as well as where this is absent, by the Yellow Loam of the surface.

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* See Miss. Rep., 1860, p. 153. The reference of the outcrop at Powe's to the Grand Gulf group is, I think, undoubtedly erroneous, and the same may be true of part or whole of the Dwyer's Ferry section, p. 154.

It would seem that here also, during the latter portion of th Drift period, most of the larger river channels were alread impressed upon the surface, though not always coincident wi the present immediate valley; as Newberry has observed i relation to some of the northern rivers. A depression of th land would gradually transform these channels into inlets fille with more or less stagnant fresh water down to a greater or les distance from the then existing coast line; and thus opportunit would be afforded for the formation of the swamp and lagoo deposits into which both the Mississippi and Red river hav subsequently cut their channels. The banks of the Red river a well as, outside the present alluvial area, those of the many lake and bayous which border that stream, exhibit strata absolutel identical in character with those observed near the coast, ye of course, totally different from either the alluvial deposits o the present time, or the adjoining tertiaries. The same hold true, more or less, of the Mississippi and its mighty "bayous.' According to the observations of Dr. E. A. Smith in the Yazo bottom, and my own in that of the Tensas, not only do th clays with calcareous concretions (as characteristic of the Por Hudson age as they are foreign to the alluvium of to-day) fre quently crop out in the beds of the streams; but much of th best lands of the "buckshot" kind, now situated above over flow, have clearly been formed by simple disintegration of thes strata, altogether independently of the river alluvium.

These results fully confirm, therefore, the statement made b Gen. Humphreys,* that the Mississippi does not, as a rule, flow in a bed formed of its own deposits, but has excavated it in an older geological formation. Wells exceeding fifteen or twenty feet ordinarily strike these clays throughout the bottom, as they do in the delta; and the analogy has been completed by the repetition of the phenomena observed in driven wells at New Orleans,† at a point about fifty miles above Vicksburg (Gen. Wade Hampton's plantation), where a tube well has fur nished a copious flow of combustible gas undiminished fo many months.

The swamp clays form, however, only the lower portion o the Port Hudson beds. Higher up, as shown at the Port Hudson bluff,‡ there lie yellow or whitish silts and "hard pans." These form, also, a level terrace some miles in width bordering the Tensas bottom; while high above it, on the hill tops of Sicily Island, on the Washita, lie the remnants of th Loess formation, the main body of which has succumbed t the erosive influence of the Terrace epoch of elevation. It has, however, left a belt a few miles wide on the eastern side of the valley, as shown on the map.

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* Rep. on the Mississippi river, p. 98, et al. † This Jour., vol. i, 1871, p. 345.
‡ See profile in this Jour., Jan., 1869.

It would thus seem that during the latter portion of the eriod of depression, the rate of sinking became, at times, too pid to allow of the accumulation of swamp deposit. The durate silts are mostly void of fossils of any kind, but are ccasionally traversed by fluviatile beds with pebbles, driftood, etc. Then there is a recurrence of the swamp deposits; en again silts; and finally, the calcareous, silty loam of the luff formation, with its numerous terrestrial fossils and "Löss uppets," ends the deposits clearly referable to the epoch of epression.

The Loess differs little from its equivalents farther north, ave in being utterly devoid of stratification as well as of any uviatile organisms. It is not easy to imagine the *modus perandi* by which a deposit of this kind, sometimes 70 feet hick, and of dead uniformity from top to bottom, could be roduced. Its equivalents farther north exhibit very distinctly he structure resulting when deposition takes place in (gently) lowing water; at the south it was probably substantially stagant, save as regards the tidal flow. Perhaps the latter may erve to explain both the absence of fluviatile as well as marine ife, and the uniform intermixture, without any semblance of rrangement, of material varying from the finest silt to pebbles alf an inch in diameter. A strong tidal wave running up a eep inlet of this kind, would naturally sweep away, in its eriodical rushes, many members of the terrestrial fauna, whose emains are in a marked degree the more abundant the nearer we approach to the edge of the formation.

Overlying the Loess we find, wherever opportunity is afforded, stratum of yellow loam or brick clay, which near the larger valleys is often as much as fifteen to twenty feet in thickness. It is altogether devoid of stratified structure, as well as of fossils, and forms the surface layer, and in most cases the subsoil of the Gulf States. If, as I am inclined to believe, its presence as a connected, though very undulating sheet, on all but the most elevated uplands of these States, necessitates the assumption of submergence, however brief, to the highest level at which it occurs; the changes of level heretofore alluded to would be shown to have exceeded by 600 to 700 feet the estimate given above.

The succeeding (Terrace) epoch of elevation has not, so far as I am aware, left any marks in the way of beach-lines or terraces, unless the second bottoms or "hommocks" be accounted such. They, however, belong to a very modern epoch, for they occur on streams no larger than what is usually called a "creek," and are most marked on the smaller rivers; while, apparently absent from those of the largest size, such as the Mississippi, Red and Arkansas rivers. The elevation at which, on the very Gulf shore, we find deposits of the Port Hudson age (180 feet at the Five Islands on Vermillion Bay) shows, nevertheless, that a stupendous amount of erosion was accomplished during the time that the Mississippi occupied in scooping out its channel, to a depth which, even below the northern boundary of Louisiana, cannot be estimated at less than 500 feet.

As regards the modern epoch, I will merely remark that, while in the axis of the ancient embayment the Mississippi river, through the singular instrumentality of mudlumps upheaval, is rapidly pushing out the land into the Gulf waters, the latter are nevertheless gaining ground on almost the entire coast of Mississippi and Alabama; and the same is true of a portion of Vermillion Bay. Yet on the whole, the coast of Louisiana, as well as that of Texas and Florida, is more than holding its own; and the shallowness of the water, even where encroachment does take place, will necessarily restrict the latter within narrow limits hereafter.

ART. L.—*On the Astromonical Proof of a Resisting Medium in Space;* by ASAPH HALL.

THE return of Encke's Comet during the present year and its very favorable position for observation will attract the attention of astronomers to this, one of the most interesting bodies of our solar system. Besides the interest belonging to all periodic comets since the establishment of the probable connection of their orbits with those of meteoric streams, this comet has a peculiar interest, since from the singular anomaly in its motion Professor Encke drew his inference of a resisting medium in space. Encke's labors on the orbit of this comet were begun in 1819; and immediately after his discovery of its periodicity, he found by comparing the observations of that year with those of 1786, 1795 and 1805, and taking careful account of the planetary perturbations, the remarkable circumstance that the periodic times were diminishing. The following values of these times were found:

1786—1795 periodic time=1208·112 days
1795—1805 " " =1207·879 "
1805—1819 " " =1207·424 "

In order to account for this diminution Encke adopted the hypothesis of a resisting medium in space. He appears to have been led to this hypothesis in the first place on account of its inherent probability, and in this view he was sustained by lbers. But the strongest proof of its truth lies in the fact hat the analytical investigation shows, that a tangential force esulting from a resisting medium would produce secular hanges in the mean motion of the body and in the excentriity of its orbit, leaving the other elements unchanged or hanged by periodic inequalities only. This conclusion is inde-endent of the law of density of the medium. Now this was what Encke needed in order to account for the anomalous motion f the comet, the change falling almost entirely on its mean mo-ion, that of the excentricity being quite insignificant. Other ypotheses were suggested to explain the diminution of the eriodic time, and especially that of internal changes in the omet itself, but nearly all of these, besides being less simple han the assumption of a resisting medium, would necessitate he introduction of forces acting in various directions, and producing anomalous changes in all the other elements of the rbit, contrary to what was required by the observations. Encke therefore, notwithstanding the doubts of Bessel and other astronomers, continued steadfast in his theory of a resisting medium in space, and for more than forty years, and until within a short time before his death in 1865, pursued his calculations with wonderful zeal and industry. Between the years 1829 and 1859, he published in the volumes of the Berlin Academy eight memoirs on the orbit of this comet, and also other investigations on the same subject in the Astronomische Nachrichten and in the Berlin Jahrbuch. He assures us, what we can easily believe, that he spared no labor and despised no precaution that could give completeness and surety to his computations; and besides being an excellent mathematician, Encke possessed, in a degree rarely equaled, the skill of adapting formulæ to convenient and safe forms for numerical calculations. He has given in the Berlin Jahrbuch for 1861 a résumé of his labors, and the proofs presented there, taken simply by themselves, seem to put beyond the shadow of a doubt two conclusions: first, that the periodic time of this comet is diminishing; and secondly, that this diminution is satisfactorily accounted for by the assumption of a resisting medium in space.

I will now state the reasons that throw doubt on the preceding conclusions, and which, I think, require that Encke's results should be tested by an independent calculation.

The position and dimensions of the orbit of Encke's comet are such that the comet can approach very near to Mercury, so near indeed, that notwithstanding the small mass of this planet, the perturbations which it may produce in the motion of the comet can exceed the greatest ever produced by Jupiter. On account of the rapid motion of Mercury, the calculation of these perturbations would be very laborious, and frequent corrections of the comet's elements would be necessary. It is well known that among the incidental results of Encke's investigations on the orbit of this comet, were the corrections of the values of the masses of Jupiter, Mars and Mercury given by Laplace. The value of the mass of Jupiter is now accurately known, but with regard to Mars and Mercury there is an uncertainty which of course it would be necessary to consider in any investigation where these masses can produce large disturbances. Considering, therefore, the great difficulty of the problem, it does not seem unreasonable to ask, before accepting any extraordinary assumption, that Encke's results should be verified by a new calculation, carried on at least through four or five successive revolutions of the comet during recent times, when the observations have been accurately made. Encke himself has given in the Berlin Jahrbuch for 1858 a new and rigorous method for such calculations.

But should it be found, as seems probable, that Encke's numerical results are correct, it would not follow that the existence of a resisting medium in space is established.

There are two other periodical comets whose motions have been carefully investigated, and which furnish important evidence on this question. These are Faye's and Winnecke's comets, discovered, or in the case of the last rediscovered, in 1843 and 1858, and which have periods of 7½ and 5½ years respectively. If we denote by q the perihelion distance of a comet, by a its semi-major axis, and by e the excentricity of its orbit, and express these quantities in units of the earth's mean distance from the sun, we shall have the following values for 1858, when all these comets were observed.

Comet.	q.	a.	e.
Encke,	0·3407	2·2181	0·8464
Faye,	1·6942	3·8137	0·5556
Winnecke,	0·7684	3.1367	0·7550

If we observe that the aphelion distance is $2a–q$, the preceding quantities will give us an idea of how differently situated in space are the orbits of these three comets, and with what different velocities they move around the sun. Thus, while Encke's comet at its perihelion approaches nearer to the sun than Mercury, and always remains nearer than Jupiter, on the other hand, Faye's comet never approaches so near the sun as does the planet Mars. Should it be found, therefore, that all these comets exhibit in their motions the anomaly found by Encke, and could this be accounted for by the assumption of a resisting medium in space, the evidence would be considered decisive. Such, however, is not the fact. The orbit of Faye's comet has en very carefully determined by Professor Axel Moéller of and, Sweden. After computing the planetary perturbations, rof. Moéller combined the positions of the comet observed in 43, 1851 and 1858, and at first thought it necessary to intro- ice, as Encke had done, the hypothesis of a resisting medium. this way he satisfied the observations of the three returns in admirable manner, and Encke in his declining years thought saw the complete proof of his hypothesis and a satisfactory ply to Bessel's objection made in 1835, "that up to the present ne we know of nothing but the motion of a *single* comet which is necessary to explain by a resisting medium in space, since e motions of the planets and moon have given no evidence a resistance." But in 1865 Prof. Moéller revised his cal- lations, and found that he had made an error in computing the rtubations, or rather in transferring the varying elements of comet's orbit from one epoch to another, and that when this s correctly done the observations were satisfied, within the its of their probable error, by a strict adherence to the law gravitation and without any extraordinary hypothesis. There- e, laying aside the theory of a resisting medium, Prof. Moéller ried forward his calculation of the perturbations, and com- ted an ephemeris for the return of the comet in 1865. This diction proved to be of wonderful accuracy. The comet s so faint in that year, that it could be seen only with diffi- ty in the telescope of the Naval Observatory, but on the t night it was looked for it was seen exactly in the predicted ce. Professor Peters of Hamilton College, who is provided h a more powerful telescope, made a series of accurate deter- nations of position and from the mean of eight days' obser- ions the corrections of Prof. Moéller's ephemeris were only

$$\Delta\alpha = +0^{s}\cdot55,\ \Delta\delta = +9''\cdot9.$$

e prediction, therefore, was one of the most accurate ever de of the return of a comet. Hence in the case of Faye's net, the weight of evidence was transferred from one scale to other; and the character of the error, which Prof. Moéller ected in his own work, is such that there is additional reason desiring that Encke's calculation should be subjected to a rous test.

Winnecke's comet was seen first in 1819, when Encke com- ed an elliptic orbit which gave very nearly the true periodic e, but the comet was not seen again until it was rediscovered Dr. Winnecke in 1858. Tbe most careful determination of orbit is that by Professor Oppolzer of Vienna. As the per- ations of this comet have not been large, regard was had he first powers only of the disturbing forces, and the calcula- s have been made with comparative ease. By combining the positions of 1819, 1858 and 1869, Prof. Oppolzer finds for the first interval the value of the mean motion 638″·6312, and for the second interval 638″·7007. This difference is so small that we may safely conclude that the comet's motion is strictly in obedience to the law of gravitation.

Hence, so far as the motions of comets have been determined, the evidence is against the theory of a resisting medium in space. Thus far, the observations of the planets lead to the conclusion, that their motions are in strict accord with the law of gravitation; and in the disputes about the acceleration of the mean motion of the moon, no one has thought to seek its cause in a resisting medium, but much more probable causes are at hand. Encke's comet, therefore, stands alone in the strange anomaly in its motion which the calculations have shown. The first thing to be done would be to test the correctness of these calculations; and for this purpose it seems to me that the method of special perturbations is better than the expansion of the general perturbations, since by the first method all powers of the disturbing forces can be rigorously taken account of, while in the method of general perturbations the theory is difficult, and in the present state of analysis a doubt may remain whether we have included in our result all terms of a sensible influence. If it be proved that the diminution of the periodic time actually exists, this anomaly must be considered as a peculiarity of Encke's comet, and its cause must be sought for in something which distinguishes this comet from all others. It was early pointed out, by Olbers I think, that this comet moves through those regions where the zodiacal light is seen. Possibly also the numerous meteoric streams which are moving around the sun, and which are closely connected with the orbits of some of the comets, may exert an influence on their motions.

Sept. 25, 1871.

ART. LI.—*On a new Micrometric Goniometer eye-piece for the Microscope;* by J. P. SOUTHWORTH.

AFTER a few experiments by Dr. H. T. Porter and myself, we have succeeded in making an eye-piece micrometer and goniometer which equal in accuracy and surpass in simplicity and cheapness any we have seen, and we have used those of some of the best makers in this country. The objection to the eye-piece micrometers in use is the want of boldness in the division-lines, which makes them fatiguing and hurtful to the eyes. To overcome this objection we were led to experiments in making micrometers by the aid of photography, which have resulted in success. The steps of the process are these:—

1st. A scale of 100 heavy India ink lines about $\frac{1}{8}$ of an inch part are drawn on a dead white surface of Bristol board. The ines marking every ten divisions are six inches long and xtend one inch each side of the scale; those marking every ive divisions are five inches long and extend one half inch eyond the scale; the remaining lines are four inches long.

2d. By photographic process for copying engravings, a negative s taken, on which the scale equals about two inches in length, nd is intensified by mercuric chloride and potassium cyanide.

3d. With a copying camera and lens for taking transparent ositives for the magic lantern, a transparent positive of this egative is taken on micrometer glass, reducing the scale to the ength of one-half inch. In this the lines are $\frac{1}{200}$ of an inch part. After intensifying, washing and drying, a cover of thin glass is cemented on with Canada balsam, and the slide cut to it the slit in the micrometer eye-piece. It can be also mounted with a spring and micrometer screw, like Jackson's micrometer. In our micrometer the lines appear to stand out in relief, and are jet black, while the spaces between them are translucent enough to admit of the accurate measurement of the details of minute algæ and fungi to the $\frac{1}{25000}$ of an inch.

Regarding the goniometer:—

1st. A circle about eighteen inches in diameter is drawn with India ink, divided into degrees. The center is indicated by a dot, and one diameter is drawn. Every five and ten degrees are indicated by longer lines than those indicating single degrees. Every ten degrees of each quadrant are numbered from 0 to 90.

2d. A negative two inches in diameter is taken by the process referred to above, and from this a transparent positive is taken on a circle of micrometer glass cut to fit the tube of the microscope. It is covered with a circle of thin glass cemented with balsam, and mounted to fit the tube at the focal point of a positive eye-piece. A cobweb is drawn across the diameter of the lower lens. When a crystal is to be measured, the stage is moved till the apex of the angle coincides with the center of the goniometer and the diameter with one side. The eye-piece is now turned till the cobweb crossing the diameter at the center coincides with the other side of the angle. Now the number of degrees of the angle can be read at the circumference. The advantage of this over the ordinary microscopic goniometers is that in ours the angles of the crystal and the degrees of the goniometer are on the same line of sight within the tube of the microscope, while in the ordinary goniometer the degrees are marked outside the tube. The photographic processes by which the above are made can be learned by consulting any of the standard works on photography, under the sections that treat of copying engravings and taking transparent positives.

Georgetown, D. C.

ART. LII.—*On the bearing of Devonian Botany on Questions as to the Origin and Extinction of Species;* by DR. J. W. DAWSON.

[The theoretical views contained in this section, though necessary to give completeness to the subject, are not suitable for an official report, and are, therefore, printed separately by the author, for circulation to those who may be interested in them as matters of science.]

FOSSIL plants are almost proverbially uncertain with reference to their accurate determination, and have been regarded as of comparatively little utility in the decision of general questions of paleontology. This results principally from the fragmentary condition in which they have been studied, and from the fact that fragments of animal structures are more definite and instructive than corresponding portions of plants.

It is to be observed, however, that our knowledge of fossil plants becomes accurate in proportion to the extent to which we can carry the study of specimens in the beds in which they are preserved, so as to examine more perfect examples than those usually to be found in museums. When structure is taken into the account, as well as external form, we can also depend more confidently on our results. Further, the abundance of specimens to be obtained in particular beds often goes far to make up for their individual imperfection. The writer of these pages has been enabled to avail himself very fully of these advantages, and on this account, if on no other, feels entitled to speak with some authority on theoretical questions.

It is an additional encouragement to pursue the subject that, when we can obtain definite information as to the successive floras of any region, we thereby learn much as to climate, and vicissitudes in regard to the extent of land and water; and that, with reference to such points, the evidence of fossil plants, when properly studied, is, from the close relation of plants to those stations and climates, even more valuable than that of animal fossils.

It is necessary, however, that in pursuing such enquiries we should have some definite views as to the nature and permanence of specific forms, whether with reference to a single geological period, or to successive periods; and I may be excused for stating here some general principles, which I think important for our guidance, with special reference to the paleozoic floras which form the subject of this memoir.

(1.) Botanists proceed on the assumption, vindicated by experience, that, within the period of human observation, species have not materially varied or passed into each other. We may make, for practical purposes, the same assumption with regard o any given geological period, and may hold that for each such period there are specific types, which, for the time at least, are invariable.

(2.) When we inquire what constitutes a good species for any given period, we have reason to believe that many names in our lists represent merely varietal forms or erroneous determinations. This is the case even in the modern flora; and in fossil floras, through the poverty of specimens, their fragmentary condition and various states of preservation, it is still more likely to occur. Every revision of any group of fossils detects numerous synonyms, and of these many are incapable of detection without the comparison of large suites of specimens.

(3.) We may select from the flora of any geological period certain forms, which I shall call *specific types*, which may for such period be regarded as unchanging. Having settled such types, we may compare them with similar forms in other periods, and such comparisons will not be vitiated by the uncertainty which arises from the comparison of so-called species which may, in many cases, be mere varietal forms, as distinguished from specific types. Our types may be founded on mere fragments, provided that these are of such a nature as to prove that they belong to distinct forms which cannot pass into each other, at least within the limits of one geological period.

(4.) When we compare the specific types of one period with those of another immediately precedent or subsequent, we shall find that some continue unchanged through long intervals of geological time, that others are represented by allied forms regarded either as varietal or specific, and as derived or otherwise, according to the view which we may entertain as to the permanence of species. On the other hand, we also find new types not rationally deducible, on any theory of derivation, from those known in other periods. Further, in comparing the types of a poor period with those of one rich in species, we may account for the appearance of new types in the latter by the deficiency of our information as to the former; where many new types appear in the poorer period this conclusion seems less probable. For example, new types appearing in poor formations, like the Lower Erian and Lower Carboniferous, have greater significance than if they appeared in the Middle Erian or in the Coal Measures.

(5.) When specific types disappear without any known successors, under circumstances in which it seems unlikely that we should have failed to discover their continuance, we may fairly assume that they have become extinct, at least locally; and where the field of observation is very extensive, as in the great coal fields of Europe and America, we may esteem such extinction as practically general, at least for the northern hemisphere. When many specific types become extinct together, or in close succession, we may suppose that such extinction resulted from physical changes; but where single types disappear, under circumstances in which others of similar habit continue, we may not unreasonably conjecture that, as Pictet has argued in the case of animals, such types may have been in their own nature limited in duration, and may have died out without any external cause.

(6.) With regard to the *introduction* of specific types we have not as yet a sufficient amount of information. Even if we freely admit that ordinary specific forms, as well as mere varieties, may result from derivation, this by no means excludes the idea of primitive specific types originating in some other way. Just as the chemist, after analyzing all compounds and ascertaining all allotropic forms, arrives at length at certain elements not mutually transmutable or derivable, so the botanist and zoölogist must expect sooner or later to arrive at elementary specific types, which, if to be accounted for at all, must be explained on some principle distinct from that of derivation. The position of many modern biologists, in presence of this question, may be logically the same with that of the ancient alchemists with reference to the chemical elements, though the fallacy in the case of fossils may be of more difficult detection. Our business at present, in the prosecution of paleobotany, is to discover, if possible, what are elementary or original types, and, having found these, to enquire as to the law of their creation.

(7.) In prosecuting such questions geographical relations must be carefully considered. When the floras of two successive periods have existed in the same region, and under circumstances that render it probable that plants have continued to grow on the same or adjoining areas throughout these periods, the comparison becomes direct, and this is the case with the Erian and Carboniferous floras in North-Eastern America. But when the areas of the two formations are widely separated in space, as well as in time, any resemblances of facies that we may observe may have no connection whatever with an unbroken continuity of specific types.

I desire, however, under this head, to affirm my conviction that, with reference to the Erian and Carboniferous floras of North America and of Europe, the doctrine of "homotaxis," as distinct from actual contemporaneity, has no place. The succession of formations in the Paleozoic period evidences a similar series of physical phenomena on the grandest scale throughout the northern hemisphere. The succession of marine animals implies the continuity of the sea-bottoms on which they lived. The head-quarters of the Erian flora in America and Europe must have been in connected or adjoining areas in the North

Atlantic. The similarity of the Carboniferous flora on the two ides of the Atlantic, and the great number of identical species, roves a still closer connection in that period. These coinci-ences are too extensive and too frequently repeated to be the esult of any accident of similar sequence at different times, nd this more especially as they extend to the more minute ifferences in the features of each period, as, for instance, the loras of the Lower and Upper Devonian, and of the Lower, Middle, and Upper Carboniferous.

Another geographical question is that which relates to cen-ers of dispersion. In times of slow subsidence of extensive reas, the plants inhabiting such areas must be narrowed in heir range and often separated from each other in detached pots, while, at the same time, important climatal changes must lso occur. On the re-emergence of the land, such of these pecies as remained would again extend themselves over their ormer areas of distribution, in so far as the new climatal and ther conditions would permit. We should naturally suppose hat the first of the above processes would tend to the elimina-ion of varieties, the second to their increase; but, on the other hand, the breaking up of a continental flora into that of distinct islets, and the crowding together of many forms, might be a process fertile in the production of some varieties, if fatal to others.

Further, it is possible that these changes of subsidence may have some connection with the introduction, as well as with the extinction, even of specific types. It is certain, at least, in the case of land plants, that such types come in most abundantly immediately after elevation, though they are most abundantly preserved in periods of slow subsidence. I do not mean, however, that this connection is one of cause and effect; there are, indeed, indications that it is not so. One of these is, that in some cases the enlargement of the area of the land seems to be as injurious to terrestrial species as its diminution.

Applying the above considerations to the Erian and Carboniferous floras of North America, we obtain some data which may guide us in arriving at general conclusions. The Erian flora is comparatively poor, and its types are in the main similar to those of the Carboniferous. Of these types a few only re-appear in the Middle Coal formation under identical forms; a great number appear under allied forms; some altogether disappear. The Erian flora of New Brunswick and Maine occurs side by side with the Carboniferous of the same region; so does the Erian of New York and Pennsylvania with the Carboniferous of those States. Thus we have data for the comparison of successive floras in the same region. In the Canadian region we have, indeed, in direct sequence, the floras of the Upper Silurian, the Lower, Middle, and Upper Erian, and the Lower, Middle, and Upper Carboniferous, all more or less distinct from each other, and affording an admirable series for comparison in a region whose geographical features are very broadly marked. All these floras are composed in great part of similar types, and probably do not indicate very dissimilar general physical conditions, but they are separated from each other by the great subsidences of the Corniferous limestone and the Lower Carboniferous limestone, and by the local but intense subterranean action which has altered and disturbed the Erian beds toward the close of that period. Still none of these changes was universal. The Corniferous limestone is absent in Gaspé, and probably in New Brunswick, where, consequently, the Erian flora could continue undisturbed during that long period. The Carboniferous limestone is absent from the slopes of the Appalachians in Pennsylvania, where a retreat may have been afforded to the Upper Erian and Lower Carboniferous floras. The disturbances at the close of the Erian were limited to those eastern regions where the great limestone-producing subsidences were unfelt, and, on the other hand, are absent in Ohio, where the subsidences and marine conditions were almost at a maximum.

Bearing in mind these peculiarities of the area in question, we may now group in a tabular form the distinct specific types recognized in the Erian system, indicating, at the same time, those which are represented by identical species in the Carboniferous, those represented by similar species of the same general type, and those not represented at all. For example, *Calamites cannæformis* extends as a species into the Carboniferous; *Asterophyllites latifolius* does not so extend, but is represented by closely allied species of the same type; *Prototaxites* disappears altogether before we reach the Carboniferous.

Of the accompanying forms, fifty-one in all, found in the Erian of Eastern America, all, except the four last, are certainly distinct specific types. Of these only four reappear in the Carboniferous under identical species, but no less than twenty-six reappear under representative or allied forms, some at least of which a derivationist might claim as modified descendants. On the other hand, nearly one half of the Devonian types are unknown in the Carboniferous, while there remain a very large number of Carboniferous types not accounted for by anything known in the Devonian. Further, a very poor flora, including only two or three types, is the predecessor of the Erian flora in the Upper Silurian, and the flora again becomes poor in the Upper Devonian and Lower Carboniferous. Every new species discovered must more or less modify the above statements, and the whole Erian flora of America, as well as the Carboniferous, requires a thorough comparison with that of Europe before general conclusions can be safely drawn. In the meantime I may indicate the

Table of Erian and Carboniferous Specific Types.

rian' Types. Represented in Carboniferous—	by identical types.	by relat'd forms.	Erian Types. Represented in Carboniferous—	by identical types.	by relat'd forms.
1. Syringoxylon mirabile,			27. Cordaites Robbii,		*
2. Nematoxylon,			28. C. augustifolia,		
3. Prototaxites,			29. Cyclopteris (Archæopteris),		
4. Aporoxylon,			30. C. (Aneimites),		*
5. Ormoxylon,			31. C. Brownii,		
6. Dadoxylon,		*	32. C. varia,		*
7. Sigillaria Vanuxemii,		*	33. Neuropteris polymorpha,		*
8. S. palpebra,		*	34. N. Serrulata,		*
9. Didymophyllum,			35. N. Dawsonii,		
.0. Calamodendron,		*	36. N. retorquata,		*
11. Calamites transitionis,	*		37. N. resecta,		
12. C. cannæformis,	*		38. Spenopteris Hœninghausi,	*	
13. Asterophyllites scutigera,			39. S. Harttii,		*
14. A. latifolia,		*	40. Hymenophyllites curtilobus,		
15. Annularia laxa,			41. H. obtusilobus,		*
16. Sphenophyllum antiquam,		*	42. Alethopteris discrepans,		*
17. Cyclostigma,			43. Pecopteris serrulata,		*
18. Arthrostigma,			44. P. preciosa,		
19. Lepidodendron Gaspianum,		*	45. Trichomanites,		*
20. L. Veltheimianum,		*	46. Callipteris,		*
21. Lycopodites Matthewi,		*	47. Psaronius,		*
22. L. Richardsoni,			48. Cardiocarpum,		*
23. L. Vanuxemii,			49. C. Crampii,		
24. Lepidophloios antiquus,		*	50. Antholithes,		*
25. Psilophyton princeps,			51. Trigonocarpum.		*
26. P. robustius,					

direction in which the facts seem to point, by the following general statements:—

1. Some of the forms reckoned as specific in the Devonian and Carboniferous may be really derivative races. There are indications that such races may have originated in one or more of the following ways:—(1) By a natural tendency in synthetic types to become specialized in the direction of one or other of their constituent elements. In this way such plants as *Arthrostigma* and *Psilophyton* may have assumed new varietal forms. (2) By embryonic retardation or acceleration,† whereby certain species may have had their maturity advanced or postponed, thus giving them various grades of perfection in reproduction and complexity of structure. The fact that so many Erian and Carboniferous plants seem to be on the confines of our groups of Acrogens and Gymnosperms may be supposed favorable to such exchanges. (3) The contraction and breaking up of floras, as occurred in the Middle Erian and Lower Carboniferous, may have been eminently favorable to the production of such varietal forms as would result from what has been called the "struggle for existence." (4) The elevation of a great expanse of new land at the close of the Middle Erian and the beginning

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† In the manner illustrated by Hyatt and Cope.

of the Coal period, would, by permitting the extension of species over wide areas and fertile soils, and by removing the pressure previously existing, be eminently favorable to the production of new, and especially of improved, varieties.

2. Whatever importance we may attach to the above supposed causes of change, we still require to account for the origin of our specific types. This may forever elude our observation, but we may at least hope to ascertain the external conditions favorable to their production. In order to attain even to this it will be necessary to inquire critically, with reference to every acknowledged species, what its claims to distinctness are, so that we may be enabled to distinguish specific types from mere varieties. Having attained to some certainty in this, we may be prepared to inquire whether the conditions favorable to the appearance of new varieties were also those favorable to the creation of new types, or the reverse—whether these conditions were those of compression or expansion, or to what extent the appearance of new types may be independent of any external conditions, other than those absolutely necessary for their existence. I am not without hope that the further study of fossil plants may enable us thus to approach to a comprehension of the laws of the creation, as distinguished from those of the continued existence of species.

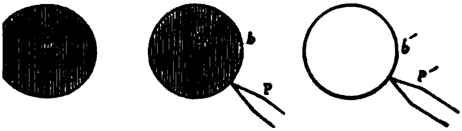
In the present state of our knowledge we have no good ground either to limit the number of specific types beyond what a fair study of our material may warrant, or to infer that such primitive types must necessarily have been of low grade, or that progress in varietal forms has always been upward. The occurrence of such an advanced and specialized type as that of *Syringoxylon*, in the Middle Devonian, should guard us against these errors. The creative process may have been applicable to the highest as well as to the lowest forms, and subsequent deviations must have included degradation as well as elevation. I can conceive nothing more unreasonable than the statement sometimes made that it is illogical or even absurd to suppose that highly organized beings could have been produced except by derivation from previously existing organisms. This is begging the whole question at issue, depriving science of a noble department of inquiry on which it has as yet barely entered, and anticipating by unwarranted assertions conclusions which may perhaps suddenly dawn upon us through the inspiration of some great intellect, or may for generations to come baffle the united exertions of all the earnest promoters of natural science. Our present attitude should not be that of dogmatists, but that of patient workers content to labor for a harvest of grand generalizations which may not come till we have passed away, but which, if we are earnest and true to nature and its Creator, may reward even some of us.

RT. LIII.—*On some Phenomena of Binocular Vision;* by JOSEPH LECONTE, Prof. Geol. and Nat. Hist., University of California.

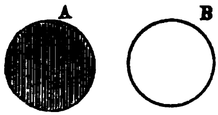
In giving my own explanation of the phenomena of M. Pic- t's experiments, I will commence with the experiment with ıe piece of money. If M. Pictet had made this experiment *ithout* the median screen, it seems to me the true explanation ɔuld not have escaped him. Let us then first try it without ıe screen.

If I place a piece of money on a sheet of paper lying on the ıble, and look downward in the direction of the piece, but at ıe same time gaze on vacancy, I see two heteronymous images, *a a′* (fig. 8), separated by an interocular space. If I now attempt to outline these images, I see also *two images of the pencil.* If I use the *ight-eye image* (left image) of the pencil *p* to draw the *left-eye mage* (right image) of the money *a′*, then I see one pencil tracng the outline *b* of the image *a′*, while another pencil makes a racing *b′* with no money in it. If I now examine the result of his experiment, I find the tracing I have made, B (fig. 9), at some distance (an interocular space) from the piece A to the right. The explanation is obvious. In gazing on vacancy, as already explained (2), the whole field of view is shifted by each eye heteronymously a half interocular space. The left-eye image of A (fig. 9) and the right-eye image of the spot B are brought together and superposed (*a′ b*, fig. 8); while the right-eye image of A and the left-eye image of B are seen to the left and right respectively (*a* and *b′*, fig. 8). It is precisely the same as the superposition of the double images of two fingers described on page 165. If, instead of using the right image of the pencil to draw the left-eye image of the money, I use *corresponding images* of the pencil and money, i. e., right-eye images or left-eye images of both, I find *I place the pencil on the money.* Finally, if I use the left-eye image *p′*, fig. 8, of the pencil to draw the right-eye image *a* of the money, I find I have made a tracing *an interocular distance to the left*, and the result of both experiments is two tracings a double interocular distance apart.

8.



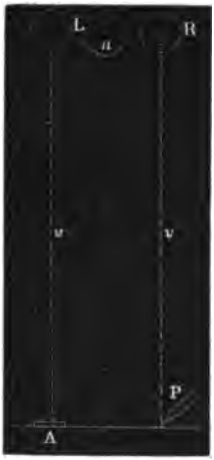
9.



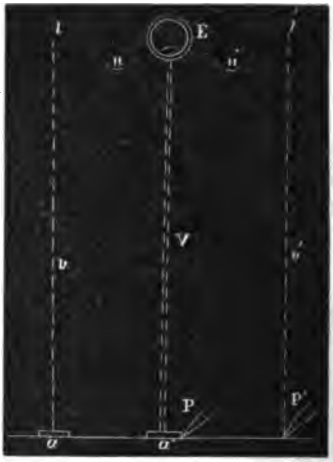
Now in M. Pictet's mode of performing the experiment, by the use of the median screen, we cut off the right-eye image of the money *a*, fig. 8, and the left-eye image of the pencil *p′*, fig. 8, and we therefore see only the left-eye image of the money *a′*

and the right-eye image of the pencil p; and these, being i the visual line of the two eyes, are brought together by the l of corresponding points (2) precisely as the two pictures o stereoscopic card are united, or as any two objects, an intero lar space apart, are superposed when we gaze at a distant poi If M. Pictet had used his *left hand to draw*, then he *would used corresponding images* of the pencil and piece; and he wou have found that in attempting to draw his *illusive* image h *would have placed his pencil on the piece.*

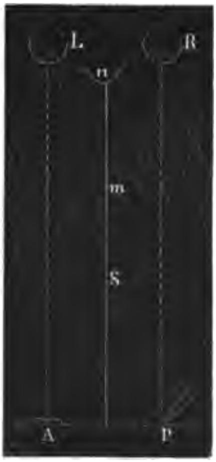
10.



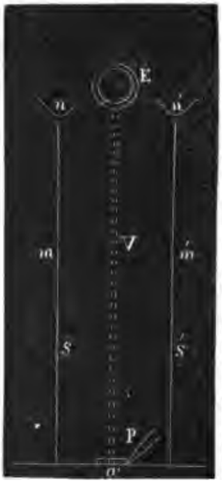
11.



12.



13.

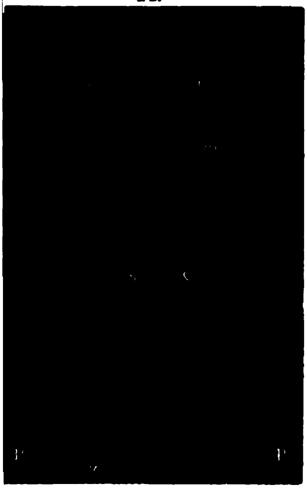


In the e periment *out* the medi screen, fig. 1 gives the act al relation parts, and f 11 represent by my method the visual re sult. In the experiment *with* the medi- an screen, the same are rep resented figs. 12 and 1 Comparing the visual resul figs. 11 and 13, it w be observed that the a ditional images, viz: and P′, are cut off the median screen.

It is evident, there- fore, that in all M. Pic- tet's experiments, th image we see and tra in outline is not an im- *age of illusion* seen by the right, but a *real image* seen by the left, eye. The pencil we see with the right eye, and the two points, viz: the pencil and money, or the part of the paper on which we make the drawing and the money, being in the visual lines, are brought together by the law of corresponding points. In M. Pictet's experiment these two, the pencil and the money, are similarly related to the two eyes, one on one side and the other on the other side of the screen—one exposed to the view of one eye and the other to the view of the other eye. If the image we draw is an illusive image seen by the right eye, then the *pencil* with which we draw must be also an illusive image seen by the left eye.

But to explain M. Pictet's experiment a little farther: When ve look *directly at the money*, M. Pictet says "we see that the verical screen is transparent throughout, and that it permits the ight eye to see the piece as through a perfectly diaphanous urface." But there are *two* transparent screens seen. The one seen by the right eye M. Pictet observes,* the other apparently scapes his observation. The truth is, when we look at the money, he heteronymously doubled images of the median screen m m' fig. 14) meet at the distance of the point of sight. The actual relation of parts is seen in fig. 7 (p. 322), in which A R and A L are the visual lines converged upon the piece A. The visual result is seen in fig. 14. It is seen that the visual line of the right eye stops at the right eye image of the median screen, while the left visual line runs parallel to its image of the median screen unobstructed to the piece a'. Again, "if we give to the optic axes a direction more parallel," says M. Pictet, "we see the image of illusion move gradually to the right, traverse the screen, and come on the right side." But again, he does not observe that there are two screens seen; and again, it is the left eye image of the screen which he neglects. In truth, as the eyes become parallel, the two images of the screen, m S and m' S' fig. 14, gradually open until they become parallel, and the piece is seen between them, as already shown in fig. 13. The *piece does not in the least change its position in relation to the creen seen by the left eye;* only the right eye *shifts its image of the creen* to the left of it. If M. Pictet would place another piece of money on the right side of the screen exactly where he made he outline tracing, he would observe the two pieces unite in one, precisely as stereoscopic pictures are united. According o M. Pictet's principles, this must be regarded as the *union of wo illusive images.* Where, then, are the real images?

14.



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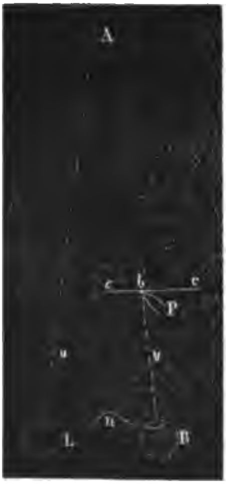
* There seems to be a kind of *dexterity* in the right eye. In many cases of ouble images, most persons habitually neglect the left-eye image.

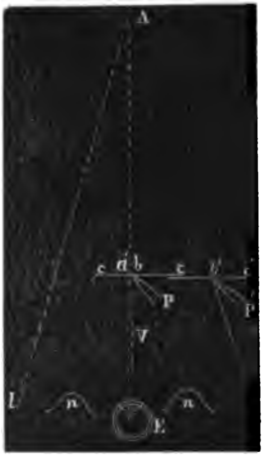
It is now easily understood that by the use of lenses before the *right eye*, in M. Pictet's experiments, the image is not affected, not because it is *illusive*, but because it is the image of the left *eye.* But if the experiment be made *without* the median screen then the true right-eye image *a*, fig. 8, will be seen to the left and *will* be enlarged. The explanation of the outlining of objects seen under the microscope is, of course, precisely the same, as is also that of the tracing on the blank half of a stereoscopic card the outline of a picture existing on the other half.

I might illustrate the subject farther in many ways, but it seems scarcely necessary. I will only remark, in passing, that by the movement of the fields of view already explained (8), it is easy, by voluntary squinting, to outline a piece of money *in any part* of a sheet of paper one may desire. I now place a piece of money on a sheet of paper lying on the table. I place the pencil on any point where I desire to make the outline; it may be 4, 6, 10 or 12 inches from the piece. By squinting, I now bring together the right-eye image of the piece and the left-eye image of the pencil, and then trace the outline. It is a little difficult, it is true, without some small object at the point of optic convergence (point of sight) to hold the axes steady, and, therefore, to make the tracing accurate. I only speak of it to illustrate the principle of making tracings of objects at any distance from the object itself. In the case of squinting, of course a median screen is inadmissible.

15.



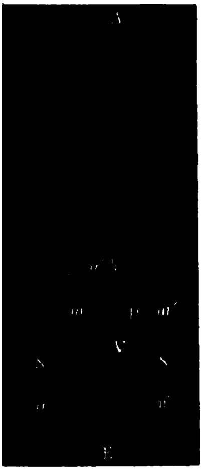
16.



The phenomena of M. Pictet's first experiment, fig. 6, will now be easily understood. If *no median* screen is used then fig. 15 will represent the actual relation of parts, and fig. 16 the visual result. By comparing these two figures, it will be seen that the two visual lines *v v* are brought together, so that the left-eye image of A and the right-eye images of the spot *b* and the pencil P, fig. 15, are brought in the same line in fig. 16; but the left-eye images of the spot *b* and of the pencil

, fig. 15, are seen to the right *b*′ P′, fig. 16. If we attempt to se P′ instead of P to make the outline, we would miss the reen. Now in M. Pictet's experiment *with* the median screen g. 6, this screen cuts off the left-eye image of the spot *b* and of the pencil P, so that we have only the left-eye image of the object A, and the right-eye image of the spot *b*; and these, by the law of corresponding points, are brought in the same line. The visual result is represented in fig. 17.

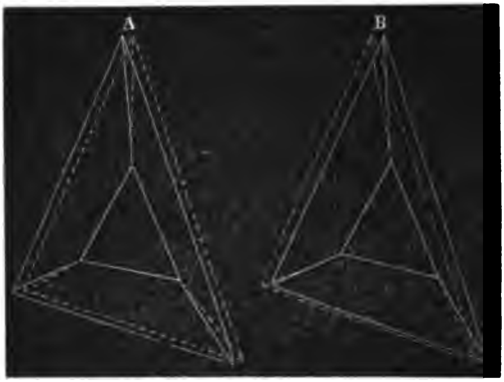
17.



As illustrating the singular confusion into which M. Pictet has fallen, I would draw attention to the fact, that in his experiments on the transparency of double images, described on page 8, as well as in the experiment last explained, the *double images* are regarded as *real*, while the *objects*, seen beyond as through a transparency, are regarded as *illusive*. But in the experiment with the piece of money, it is one of the *double images* which he regards as illusive.

It is unnecessary to follow M. Pictet through all his experiments, as the same principles of explanation apply to all. There is one more point, however, which I wish to take up at some length. It is the *theory of binocular relief*. I wish to show the fallacy of M. Pictet's views, and at the same time to bring out more distinctly than I have ever yet done my own views on this important subject.

M. Pictet believes that, in every act of binocular vision, there are *four external images* formed; that *each eye* has its own *real* image, produced by the luminous retinal image, and its *illusive* image, propagated from the luminous impression of the other eye, and identical with the real image of the latter; that, as the two real images differ slightly from each other, being taken from different points of view, so do their fac-similes the two illusive images; also, necessarily, that the real and illusive images of each eye differ precisely, as do the two real images or the two illusive images. He believes that *the perception of relief is the result of comparison by each eye of its real with its illusive image.* Now what advantage this theory has over the usual and simpler one of Brewster, Prevost and Brücke, considering the fact that the real and illusive image of each eye differ precisely as do the real images of the two eyes, it is impossible to imagine. But M. Pictet regards the existence of the four images not as a question of advantage, but as a question of fact. "A very simple geometric construction shows us thus four images identical, two to two." I reproduce M. Pictet's figure illustrating this point. The full-lined figs. A and B are two projections of a truncated pyramid, as seen by the left and right eye respectively. On the same smaller or upper base, two dotted-lined figures are drawn in such wise, that each dotted-lined figure is exactly similar to the other full-lined figure. These four figures, according to M. Pictet, represent accurately the four images formed in looking at a single truncated pyramid, the full-lined figures being the true and the dotted-lined figures the illusive images. For, says he, "if we unite in one single image these four contours (by means of a stereoscope), we experience instantly the impression of a solid body; and we see that in fact the dotted lines are covered by the full lines in the binocular image, *which confirms our deduction*" (p. 141).



Now, according to the usual theory of binocular relief, viz. that of Brücke, Prevost and Brewster, how could it be otherwise? By construction, each dotted-lined figure is the fac-simile in form of the other full-lined figure, so that when their common faces, the small triangles, are united, the full-lines of the one figure *must* coincide with the dotted lines of the other. M. Pictet has therefore, by his dotted lines, only represented in *each* of his figures what must take place in the *binocular combination of his two full-lined figures*, if there were no dotted lines present; viz., the doubling of the lines of the larger triangles or lower bases, when the small triangles or upper bases are perfectly united; a fact well known to every accurate observer, and which forms the foundation of Brücke's theory.

Brücke, Prevost and Brewster explain the perception of relief by rapid changes of optic convergence, by means of which different parts of the two dissimilar images of the same object, or of two stereoscopic pictures, are successively united. In M. Pictet's full-lined figures, for example, when the smaller triangles are united, the lines of the larger triangles are slightly doubled; and when, by less optic convergence, the larger triangles are perfectly united, then the smaller triangles are doubled. Thus, the alternately greater and less convergence necessary to unite successively different parts of the pictures—the ranging of the point of sight back and forth—precisely like that which takes place, in natural vision, in looking successively at nearer and more distant objects, or nearer and more distant parts of the same object, gives a distinct perception of relief.

No one who has carefully analyzed his visual impressions, either in natural vision or in stereoscopic combination of pictures, can for a moment doubt that there is in all cases *a change of optic convergence* necessary to unite the different portions of a stereoscopic picture or of a natural solid object; and that Wheatstone's idea of a *complete mental combination* of dissimilar images, though still supported by great names, is certainly erroneous. In my own case, the doubling of objects in the foreground of stereoscopic pictures, while I look at the background and *vice versa*, is as plain as any other phenomenon of vision. It is impossible for me to doubt what I see so plainly. Precisely similar phenomena I detect with ease in viewing solid objects. Brücke and Prevost are therefore certainly *right* in insisting, against Wheatstone, on the *impossibility of complete union* of all parts of a stereoscopic picture of an object at the same moment; but they are, I believe, as certainly *wrong* in insisting *on changes of optic convergence* as absolutely *necessary to the perception of relief.* It is possible to perceive relief—even *while looking steadily at one point* in a stereoscopic or in a natural scene. Dove's much quoted experiment seems to prove that we can distinctly perceive stereoscopic relief by the light of an electric spark, which according to Wheatstone's celebrated experiment lasts only $\frac{1}{24000}$ of a second; a time too short to allow *change* of optic convergence. The relative distance of objects, I think, without doubt, can be distinctly perceived by the light of a flash of lightning, which according to Arago lasts less than $\frac{1}{1000}$,* and according to Rood $\frac{1}{500}$† of a second. These facts seem to prove that stereoscopic relief can be perceived *instantly* and *without change of optic convergence.*

This point is evidently one of capital importance in the theory of binocular vision. The *instantaneous* perception of relief is evidently *fatal to Brücke's theory.* With the assistance of my brother, Prof. John LeConte, I have, therefore, recently made a series of experiments to test its correctness. These experiments entirely confirm Dove's results, and establish beyond doubt the instantaneous perception of relief.

The apparatus used in these experiments was a first-class Ritchie's induction coil, capable of producing with ease 12-inch sparks. The contact-breaker was of such kind that the rapidity of the sparks was completely under the control of the operator. A Leyden jar was introduced into the circu in order to increase the brilliancy of the sparks. The spa were 1–2 inches in length. I selected stereoscopic pictures i which all *other* forms of perspective were entirely wanting, s that *no relief was visible with one eye.* Outline geometri figures are best for this purpose.

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* Arago, Œuvres complete, tome 4, p. 70. † This Jour., III, vol. i, p. 15.

I first viewed these in the stereoscope by the continuous lig of a rapid succession of sparks, until the stereoscopic combi tion was perfect. On making the sparks separately at lo intervals, the *relief was still perfectly clear* and unmistakab On shutting one eye, the sparks continuing at intervals, t relief disappeared; on re-opening, it immediately re-appeared

I next tried combination of the pictures with *the naked e by squinting.* This method is entirely removed from any su picion of fallacy arising from any other kind of perspectiv since, as already stated in my previous paper,* the binocul perspective is *inverted*, and therefore, must overbear all oth forms of perspective where these exist. By a rapid successi of sparks, the combination was easy and the inverse perspec tive perfect. When the sparks were made with long interval between, *still the relief was clear* and unmistakable. Shutting one eye the relief disappeared, but immediately reappeared o re-opening.

When I first commenced my experiments by either of the methods, but especially the last, a rapid succession of spar was necessary to effect combination. After the proper axi adjustment was once obtained, it could be retained witho difficulty in the interval of darkness. After some practi however, the rapid succession of sparks was no longer necessar The combination was effected, and the relief perceived by se- *rate flashes alone.*

Lastly, I tried natural vision. Two small objects, (bra balls mounted on wires) were placed one beyond the other a the distance of five or six feet, and separated from each by space of about 1 foot; sometimes in the median line, and som times one of them a little out of the median line, but in a cases so arranged *that their relative distance could not be dete by monocular vision*, even in the full light of day. By th spark their relative distance was *at once detectable with two e* though *not with one.* This last experiment was varied in man ways, but always with the same result.

Stereoscopic combination by squinting requires considerab practice, even in the full light of day, and of course mu more by the electric spark. All the *other* experiments we repeated by my brother, and my results confirmed.

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* III, vol. ii, p. 1.

I. Pictet *rightly* urges Dove's experiment on the instantan- s perception of relief as fatal to Brücke's theory, but *wrongly* onfirming his own. The objection applies equally to both. oth cases there is a judgment formed from a comparison of imilar images or pictures, and it can make no difference ether the images are real or illusive, or whether one be real one illusive, since the illusive image behaves in all respects under all circumstances, precisely like the real image of other eye.

'he only *true* explanation of the instantaneous perception of ef is, I believe, that given in my paper recently published.* already stated (3), all objects or points, either beyond or on side the point of sight, are doubled, but differently, the ner *homonymously* the latter *heteronymously*; the double ges of the former are united by *less*, the latter by *greater con- rence.* Now the observer *knows instinctively and without trial*, any case of double images, *whether they will be united by ter or less convergence;* and therefore, never makes a mistake attempts to unite by a wrong movement of the optic axis. ther words *the eye instinctively distinguishes between homony- s and heteronymous images, referring the former to objects or ts beyond, and the latter to objects or points on this side, the t of sight.* My own theory of stereoscopic relief, then, is : The eye perceives relief *instantly*, by means of double ges, as just explained; but the perception is made much rer by *changes* of optic convergences, by ranging the eyes k and forth from foreground to background and *vice versa*, the successive combination of different parts of the object ictures, as maintained by Brücke.

n regard to the relative merits of the nativistic and empiris- theories, i. e., whether corresponding points are such con- itally or become so by experience, I quite agree with Don- , that there is truth in both views. In a letter to Prof. dall, published in the Phil. Mag. for April, 1871, referring he question whether the "*law of direction*" was native or iired, I have said that instinct is nothing but "*inherited rience.*"† Precisely the same remark applies to the law of esponding points. *It is acquired by the experience of succes- generations transmitted by the law of inheritance, and made perfect by individual experience.* The inherited experience reater in the lower animals, the individual experience is ter in man. Binocular single vision is therefore, to a large nt, instinctive even in man, and much more so in lower nals. Doubtless, this is equivalent to saying that there is e *structural arrangement* in the nervous centers which deter-

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'his Jour., III, vol. ii, p. 1, et seq.

had not then seen the similar view of Hering, viz., that instinct is "inherited ory."

mines single vision by corresponding points ; but whether is any such *fusion* of corresponding fibres as suppos Müller, or any such reflection of illusive images from eye as supposed by M. Pictet, can never by determined by anatomical investigation ; and even if so determined affirmative, could not possibly show itself in any visual ph menon, since by supposition every such *illusive* image mus absolutely identical with, and absolutely inseparable fro *real* image seen by the other eye.

Oakland, California, June 9, 1871.

ART. LIV.—*The American Spongilla, a craspedote, flag Infusorian;* by H. JAMES-CLARK, A. B., B. S., Prof. Hist., Kentucky University, Lexington, Ky. (With a Pl

THE argument of Hæckel, and others, that the Sponges essentially compound Polypi, is virtually based upon the sumption that the minor (afferent) and major (efferent) oscu of the former correspond to the mouths of the latter ; and th the profusely branching afferent and efferent canals of the Spo ges are strictly comparable with similar canals in the polypid of Halcyonarians: and, by implication, that the cilia-bear cells of the interior, lining-wall of the Zoöphyte find their hom logues in the ciliated, cell-like bodies of the interior chamb of the Porifera. If, now, it should turn out that these last not altogether mere cell-components of a tissue, but are ea severally, an independent body, although closely connect with others in a common bond, then the attempted parallel between the two groups must utterly fail of confirmation. T tendency of Carter's later investigations, and our own too, show that this is no vain supposition.

For ourselves, we hold that each *ciliated body* of the Spo is a *cephalic* member (a *cephalid* in this case) of a polyceph individual.* We believe, as far as we can understand his decided, rather hesitating position, Carter's latest decision that the Sponge is a community of Amœbous individuals,† not a polycephalic unit. Yet, whichever view prevails, tendency is the same, and the Polyp theory is negatived unquestionably. The incompatibility of the interior organ of the two groups, above mentioned, is so great that it w seem as idle to elaborate a proof of it, as to attempt the dem stration of an axiom. The question is really circumscri ording to the method of Hæckel, to arguing that, since a sys- ı of branching canals in the Sponge reminds one very ngly of the intricate network of passage-ways in the basal ts of certain Polyps, therefore the two are homologous, and r an identical relation to the rest of the organism. Carter ı *new Sponges, &c.*, Ann. Mag. Nat. Hist., July, 1871) has an- red this far-fetched homology with considerable detail in cent paper; and we do not, therefore, feel called upon to l more to it.

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* See our article on "*Polarity and Polycephalism*," this Journal, January,

† See Carter, *On Fecundation in the two Volvoces; on Eudorina, Spong* Annals and Magazine Nat. Hist., January, 1859; also for July, 1871, *Sponges*, &c.

The principal aim of this article is to furnish new material proof of the polycephalism of the Spongiæ, and particularly regard to their relation with the *Protozoa Flagellata.* We highly pleased to find that Carter has lately (ut sup., July, '71) confirmed our earliest observations* as to the organization he collar-bearing monads of *Leucoselenia*, by an investigation *Grantia compressa.* He has also accepted our interpretation he horn-like processes of the sponge-cell of *Spongilla alba;* t they are the outlines of a membraneous collar in profile.

We have now to bring forward a fourth example of a *cras- ote*, flagellate monad-cephalid in a Sponge. It seems to be *Spongilla*, but specifically, at least in its monads, it differs m the English forms. For convenience sake, we will call it *ongilla arachnoidea*, from its resemblance to an irregular der-web. It lives in fresh water streams and ponds, usually ut the bottom of the stems of water-plants, or wherever re is considerable shade; apparently avoiding the light, as seldom, if ever, found it in open water. In size it varies m a few inches to half a line in diameter; of no definite pe; and has a uniform fuscous or yellowish-brown color; is wrapped about by a filmy, transparent, colorless enve- e ("*investing membrane*" Carter). The brown color is inherent the interior mass, in which the groups of monads are im- dded; in fact the latter are themselves as strongly colored by wn granular contents. The "investing membrane" is also ghtly tinged with amber color by the large and small spicules ich are imbedded in it. Excepting in very small specimens, eign matter is often so thickly spread over the surface as to cure the view and seriously interfere with a correct inter- tation of the relation of parts. We have been most fortunate our endeavors with the minuter individuals, which occasion- y, we found, would allow a view through and through their en- bulk, and of course left full opportunity for a satisfactory dy of the details of special parts, without our resorting to the secting needles. Anyone who knows, by experience, the in- se contractility of the living sponge, can appreciate the ad-

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Memoirs Boston Soc. Nat. Hist., vol. i, 1867, "*On the Spongiæ Ciliatæ as In- ria Flagellata.*"

vantage of not being obliged to destroy and sever parts o organism from their natural relations. Premising thu everything has been studied "in place," even to the det the monads, we shall endeavor to describe this sponge as were to be the type for future comparison.

General plan.—The whole individual sponge is endo with a double envelope (fig. 1 a,a^1, c, d,) the outer and in parts of which are directly continuous into each other at m points. The outer division (a, a^1) lies at a considerable dis from the monadigerous mass (g), and is, as it were, suspend on the points of the larger, far-projecting spicules (e); just a tent canvas is supported on the ends of poles. The inner vision (c) closely embraces the monadigerous mass like epidermis, and even plunges between the hollow group monads, forming to them a basis of support. The outer a inner divisions are continuous with each other at many poi as stated just now, but only where the larger spicules proj There the envelope (d) runs along the spicules, completely e bracing them, as if in a sheath, from their tips to their bas where they rest on the brown mass of monads. In brief, might say that the sponge is covered with a miniature col nade, whose ceiling is the outer division of the envelope, pillars are the bundles of spicules, and the floor is tapestried the inner division, which about the pillars hangs from the ce ing in lofty folds. The continuity of the outer division of envelope is broken by numerous, round or oval openings various and frequently changing sizes, sometimes very la which allow a free ingress of the water to the space just b neath. These are the *afferent ostioles* (os), through and i which a constant current of floating particles may be seen m ing with considerable vivacity. Here and there, scattere wide distances, finger-like, hollow processes from the oute vision arise singly, and at various angles. Each is termina by a large aperture, the *efferent ostiole*, from which a cur of water and floating matter emerges with more or less sp modic irregularity. The smaller individuals, from half a to half an inch in diameter, possess only one such ostiole: those an inch in diameter seldom have more than two or th like conduits; but they are very large, sometimes a quarter an inch in length when fully extended, and of the proporti and taper of the human forefinger.

Plunging the focus of the objective to the floor of the col nade, the inner division (c) there is found to be pierced much more numerous openings (i), but far smaller in diam and quite methodically arranged, each one correspondin and overlying a hollow group of monads (h). The outer di ion is further embellished with irregularly scattered m icules (e^1), which lie imbedded in the cytoblastema, parallel th the surface of the envelope, and occasionally crossing ch other at various angles. To complete this general sketch, will state more definitely the relation of the constituents of e monadigerous mass. There are essentially but two ele- ents here; namely, the inner division (*c*) of the investing embrane, and the groups of monads (*h*) which are imbedded it, below its surface. In a fully expanded individual these oups seldom lie so closely as to touch each other. They ry considerably in size and are usually globular or spheroidal, d form a single *stratum*, with rather narrow interspaces (c^1) tween them.

It seems proper here, at least for the sake of precision, that e *cytoblastematous basis*, in which the monad groups are im- dded, should be considered apart from the epithelium-like, ner (*c*) investing membrane which overlies it, although the o are essentially one; the epithelioid membrane, by prolong- g itself between (at c^1) and beneath the groups, forming for em a continuous foundation. In this light, then, we shall eak of the monadigerous mass as consisting of three elements, mely, the inner investing membrane proper, the group of onads, and the *cytoblastematous basis*. This *basis* seems to nstitute a large part of the bulk of the body, since it occupies l of the interior space beneath the monad groups. In speci- ens which grow over flat surfaces in depressed patches, or ound stems of plants, it forms a relatively thin layer; but here the body stands out an irregularly rounded mass, some- mes an inch in diameter, the cytoblastematous basis fills up e interior, in enormous proportion to the bulk of the monad yer.

ORGANOGRAPHY.

The Investing Membrane.—The *investing membrane* (fig. 1, *a*, , *c*, *d*,) consists essentially of two histiological elements, namely, very diffuse *cytoblastema* (a^1) and irregularly disposed cells , b^1, b^2) scattered through it. The intercellular *cytoblastema* rms a very thin layer (a^1) between the cells (*b*); but where e latter are imbedded in it, its outer and inner faces are as wide part as the considerable depth of the cells demand; and thus happens that the membrane (both the outer and the inner ivisions) presents in profile (a^1, *c*, *d*) such an irregular thickness. he *cytoblastema* (a^1) is colorless, hyaline, and apparently homo- eneous under a low power; but, when magnified to about four undred diameters, it displays a very finely granular aspect. t occupies wide intervals between the cells, certainly more than ne-half, and fully three-fifths of the whole area of the mem- rane. Its apparent extent, in a general view, is even more than that, owing to the extreme transparency of the cells, and their consequent inconspicuousness. That the cytoblastema, notwithstanding its low undeveloped state, is the true contractile element in this membrane, there can scarcely be a doubt, when we consider both its wide spread preponderance, and its relative continuity, as contrasted with the scattered, disconnected condition of the cells (b^3) which are imbedded in it. Sometimes it is barely possible to discover even the trace of a cell on the border of an afferent ostiole (*os*), and in that case we must infer inevitably, that it is cytoblastema which opens and closes the aperture. We find it, too, embracing the extreme tips of the larger spiculæ, where the cells utterly fail to appear.

The *cell-element* (*b*) of this membrane is also in a lowly condition; only partially developed. There is no *cell-wall*. What may appear to be a wall is really the thin stratum of cytoblastema (a^1) overlying the distal and proximal faces of the cell. This is our conclusion after the most critical scrutiny, with a carefully-corrected objective. Were it not, indeed, for the usually constant presence of a distinct nucleus (*n*) in each cell, we would be strongly inclined to look upon it as merely a dense collection of coarser granules than are generally diffused through the cytoblastemic layer. The irregular and jagged outline, and the caudate projections of the cells (b^2) also tend to tempt one to the latter view. The cell element in this case, then, corresponds only to what is usually considered the cell contents, and a nucleus. The contents are composed of coarse and fine grey granules, which at times are quite conspicuous, but most frequently are so transparent and slightly refractive as to appear, collectively, unless specially focussed upon, as a faint blotch in the investing membrane. This renders it all the more difficult to trace the outline of the cell, and particularly where it throws out irregular, caudate prolongations, to blend with those of other cells. We have been able to detect but one layer of cells in this membrane* when it is well stretched out. The depth of the cells, as may be seen in a sectional profile view (*b*), is about equal to their breadth, and their length is from one-half more than to twice their breadth; but frequently they are as broad as long. They stand in no particular relation to the ostioles; and, as stated above, sometimes scarcely touch their border. The *nucleus* (*n*) may be readily detected by its peculiar, strong refraction, and its considerable superiority in size over the granules. Its bright refractiveness in this connection reminded us of a contractile vesicle, but, although suspecting it of such a function, we could detect no change other than might be produced by the varying length and breadth of the cell, and the ifting of the relative position of the coarse granules. In the *ier division* (*c*) of the investing membrane the cells are usually aller than those in the outer division, but differ in no respect, ierwise, neither in form nor arrangement. They lie flat on ir sides in the cytoblastemous layer; but, except in profile, y are most difficult to discover on account of the underlying own mass of monad-groups and granular interstitial substance. Although we have been unable to discover any distinct cell ments in the cytoblastematous mass immediately around and neath the monad groups, neither have we found it possible to tinguish it from the cytoblastema lying on the surface; and ce the continuity between the two is unbroken, we must, per- ce, consider them as one. The underlying portion of the toblastematous mass, however, is characterized by irregularly ttered, moderately coarse, brown granules (c^1). These serve y well as a dark frame or setting to the monad-chambers (*h*), d by contrast brings them out more strongly.

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* Carter figures two or three cells overlying each other in *Spongilla alba*. Ann. Mag. Nat. Hist., July, 1857, Pl. 1, fig. 7.

The Monad-cephalids.—We now proceed to describe the most ential feature of this animal, the *monads*. They are the racterizing, the dominating element, in reference to which whole organism is contrived and constructed. They are cells; they are the *heads* of a polycephalic individual, and sequently correspond functionally to the tentaculated heads Polypi, and not to their interior epithelial cells. We must t describe what we call the monad-chamber.

The *monad-chambers* (fig. 1, *h*; fig. 2; fig. 4) are deep, spher- l hollows which form the receptacles of the groups of monads . They are mere cavities, and have no lining wall.* They y be easily recognized, in young specimens, as clear, more or s circular, areas scattered in pretty close proximity to each er over the "cytoblastemic mass." Each chamber has a gle, small, circular aperture (*i*) which perforates the inner (*c*) esting membrane, and allows egress into the circulatory rtment (*f*). The aperture (*i*) varies in size at times, and y, even, be completely closed. We have never seen it open ler than one-third the diameter of the chamber, and very ely more than one fifth as wide. That it is a true perfora- n, and not a clear spot, may be demonstrated by bringing a mber into profile, so that its aperture (fig. 4, *i*) lies on the reme border, and then an actual break in the continuity the investing membrane becomes evident.

The hollow groups of monads were originally described by Carter (Ann. Mag. . Hist., July, 1857) as lining an hypothecated vesicle, which he named the pullaceous sac." He has since (Ann. Mag., Jan., 1859) revoked that view and ted another. We believe him to be, excepting the inferred "ampullaceous " in the main, right in his first interpretation; but as our species are different annot speak definitely.

Entering this aperture we do not meet with any obstacle for a little distance around it; there is a clear open space (fig. 4); but pressing onward beyond that, either to the right or the left or directly forward, the cavity appears filled by a collection of vibrating bodies. They seem to be arranged radiatingly from and about the center. Close inspection, however, modifies this view, and it turns out that they are based upon the periphery of the chamber, and converge toward its center, where is a small unoccupied space. We presently recognize these converging bodies to be *craspedote, flagellate* monads (*j*), so closely packed together, side by side, as to form a continuous *stratum* (figs. 2 and 4) over the whole concave face of the chamber, excepting immediately about the aperture. Every feature of the monad is strongly marked; even the cylindrical collar is so heavy and conspicuous that its outlines may be seen with as low a power as two hundred diameters. We have studied these bodies with an ⅛th-inch objective, and found it not at all difficult to focus down upon the details of their organization without pressing upon or even touching the specimen.

These monads are in every general essential identical with those which we originally found in *Leucoselenia*, and like those, also, recently described by Carter (Ann. Mag. Nat. Hist., July, 1871), in *Grantia compressa*. They are attached to the concave face of the chamber by their posterior end (fig. 4, *j*); and the anterior extremity, with its flagellum (fig. 3, *l*) and collar (*k*), projects freely into the open space, and toward the center of the apartment. When fully expanded, the length of the body and collar together is about one-third, or a little more, of the diameter of the chamber; so that nearly one-third of the latter is unoccupied at the center, except by the tips of the flagella converging from every direction. As the monads lie touching each other on every side (fig. 2), they mutually flatten their bodies, sometimes so much as to give them a strong polygonal outline; or, when the whole mass is expanded, they scarcely impress each other, and therefore retain a rounded contour. By plunging the focus so as to look into the aperture of a chamber, down upon the monads at the bottom (fig. 2) of it, an end view of each cephalid is obtained. From this point the foreshortened cylindrical collar looks like a strong, dark circle (fig. 3ª, *k*), which retains its conspicuousness as we plunge down further, even to the base, where it is attached to the body (*j*). The outline of the latter is considerably without the "dark circle," the two being concentric to each other. At the same time we see in the center of the dark circle a black spot (*l*) which may, also, be focussed up and down upon, and hence it is inferred to be a continuous line foreshortened. Other views (fig. 3, *l*) confirm this, and show that it is a single *flagellum*.

The monads are so transparent, and the organization so distinct, that the collar and flagellum may be seen clearly from an opposite point of view, looking directly through the body of the cephalid. This, too, is the best position from which to study the *contractile vesicles.*

A sectional, profile view of a group (fig. 4), to be obtained by plunging the focus half way through a chamber, serves best to disclose the manner in which the posterior ends (*j*) of the monads are affixed to the concave face of their receptacle; and we, also, here obtain a strictly profile aspect of a monad. Figure 3 is such a view, representing a single cephalid, under a much higher power than in figures 2 or 4. An excellent and least obstructed side-view, but not strictly a profile, is to be had by focussing upon the monads immediately about the aperture of the chamber. Here we look directly into the door-way, or through the bordering, transparent epithelioid membrane which it penetrates.

The body, proper (fig. 3, *j*), of a cephalid is a little shorter than it is broad; on the whole spheroidal in shape. Its posterior end is broadly rounded, and so is its anterior extremity, In front arises a cylindrical, membranous "collar" (*k*), which tapers slightly and projects forward to a distance equal to considerable more than twice the length of the body. Its diameter is not more than two-thirds, or even less than that of the body. Although colorless, and homogeneous, it is remarkably conspicuous on account of the thickness of the membrane of which it is composed. Near its open extremity it is more transparent and less obvious than toward its basal attachment.

The *flagellum* (*l*) arises from the center of the anterior end of the body, in the midst of the area which is surrounded by the membranous cylinder (*k*), and without tapering extends a little farther than the open end of the latter. It vibrates usually throughout its length, but is most active near its tip. We have never seen it assume a rigid, arcuate position, as in some other species of monads. It is particularly remarkable for its want of transparency, and looks like a black thread more than any vibrating cilium that we have ever met with. Its action, at times, is rather that of a strong wriggle than a vibration.

The *contractile vesicles* (*v*).—The body of the monad is distinctly marked by a coarse, scattered, brown granulation, with two or three rather large, clear spots, at a considerable distance from each other, but always close to the periphery. These clear areas are the *contractile vesicles* (*v*). They do not occupy any particular place in the body, although they, usually, are not in front. The systole and diastole are extremely slow, but very distinct, if sufficient patience is summoned to watch them fixedly, and without interruption. The last third of the systole is abrupt, and then only does the vesicle appear to contract suddenly; whereas by watching it through a complete circuit of diastole and systole, one learns that its function is, on the whole performed very slowly. This very abrupt movement, quite happily, may serve to rebut any such objection as that its otherwise tardy action is merely the result of protoplasmic contraction of the body, as in certain Palmellate Zoöspores. The immovable position, as regards the body contents, is another item of rebutting evidence.

The *Spiculæ* (fig. 1, *e*, *e*') are very slender, slightly curved, needle-shaped bodies, gradually tapering to a sharp point at each end. They have a bright amber color, and a rather dark, strongly refractive outline. From tip to tip they are slightly roughened by irregularly scattered, low, but acute prominences or knobs. There are two kinds of spicules, large and small but they differ in no other respect. The larger (*e*) are from four to six times longer and thicker than the smaller ones. They occur in bundles of two, three or four; and act as props to hold up the outer investing membrane, as described in the early part of this article. They seldom arise perpendicularly from the monadigerous mass, but more or less obliquely; and, in forming bundles, stand across each other like stacked arms. We seldom found spicules penetrating the monadigerous mass far beyond the epithelioid, inner investing membrane. They evidently belong, universally, to the investing membrane, and assist it in forming a framework in which the inner mass is suspended. The *smaller spicules* (*e*') are strictly confined to the outer division (*a*) of the investing membrane, and lie there on their sides, completely immersed in its thickness. They are scattered irregularly and sparsely about, and frequently cross each other at varying angles. We observe no nearer approach to a methodical arrangement among either the large or the small spicules; yet their very irregularity, being after a kind, and constant in that kind, may be recognized in some sense as methodical.

General considerations.—Seeing the secluded position of the monad-cephalids, deeply ensconced in little chambers below the general surface of the circulatory apartment, it is not directly evident that their *flagella* have any agency in keeping up the inflow and outflow of currents through the afferent and efferent ostioles. Nowhere else are vibrating or non-vibrating cilia or cilia-like bodies to be met with than in the monad chambers. And since the efferent ostioles are irregularly interspersed among the much more numerous afferent ostioles, we cannot conceive how the flagella in any way could influence currents to move in a particular direction, from the smaller apertures toward the larger ones. They no doubt keep up a direct flow of matter into the sunken chambers, but the current comes from the inner depths of the circulatory apartment, and far away from the ostioles. In this way only a turbulence of floating matter is sustained, but the general, great current is due to a far different cause. We conceive that the contraction and expansion of the body-mass in general, modified by the alternate opening and closing of the afferent and efferent ostioles, is the true motive power in this phenomenon. We have observed, often, that the outer division of the investing membrane is not kept at a uniform distance from the central, monadigerous mass; at one place it will be found to be close to its inner division, so that the circulatory apartment is very shallow there, while at another point the two divisions of the membrane are widely separated, and the circulatory apartment is very deep; and between the shallow and the deep apartments a curtain is drawn, more or less completely, extending from one pillar-like bundle of spicules to another. Each of these temporarily enclosed portions of the general apartment, it is plain now (although our actual observation on this point is very defective), may contract or expand without disturbing the contents of any other. Such an apartment with its afferent ostioles closed, may be contracting and forcing a current out at its efferent ostiole, while a neighboring apartment may have its efferent ostoile closed, and expanding, draw in current through its open afferent ostioles.

We regret that we have not the means, in this locality, for completing these researches. Our specimens were gathered, and studied on the spot where they lived, in the western part of Massachusetts, several hundred miles away from our present residence. Unfortunately we put off the attempt to feed the sponge with colored matter until we had completed other methods of investigation, and then we were prevented, by circumstances, from carrying out our designs.

In regard to the afferent and efferent canals, seen by Carter (Ann. Mag. Nat. Hist., 1857, *ut sup.*) in the monadigerous mass ("*parenchyma*" Carter), we have not met with any trace of them in the species described in this article. It is possible that they may exist in the oldest and largest individuals, but as we worked, only, on very small and transparent specimens, our direct observations, in this respect, strictly apply to the latter. It is more likely that ours is a different genus from the *Spongilla* of Carter, in favor of which we cite the curious fact that each aperture, in the inner division (not mentioned by Carter) of the investing membrane, exactly overlies and is inseparable from the entrance to a monad-chamber ("*ampullaceous sac;*" *partim*, Carter); so that whatever enters these chambers must go out by the same way that it came in; not out into a system of branching canals, burrowed in the monadigerous mass, but in the great circulatory apartment.

Spongilla arachnoidea Jas-Cl.

DESCRIPTION OF FIGURES OF PLATE II.

The following letters apply to identical parts in all of the figures. *a*, Investing membrane; outer division.—a^1, Sectional profile of the cytoblastema of *a*.—*b*, Cells in the thickness of *a*.—b^1, Cells (like those at *b*) about the spicules (*e*).—b^2, Cells of the investing membrane, with their nucleus; a surface view.—b^3. Temporary junction (by contact only) of the outer (*a*) and inner (*c*) divisions of the investing membrane.—*c*, Investing membrane; epithelioid inner division, in sectional profile.—c^1, Interspaces between monad-chambers.—*d*, Junction of the divisions of the investing membrane along the spicules.—*e*, Larger spicules.—*e*, Smaller spicules.—*f*, Circulatory apartment.—*g*, Monadigerous mass.—*h*, Monad-chambers and monad groups.—*i*, Aperture of *h*.—*j*, Monads, or the body proper in figs. 3 and 3*a*.—*k*, Cylindrical collar of *j*.—*l*, *Flagellum*.—*n*, Nucleus.—*os*, [illegible] ostioles.—*v*. Contractile vesicles.—

Fig. 1. Magnified 320 diameters. Part of a very young *Spongilla*, of an oblate spheroidal form, and about $\frac{1}{25}$ of an inch in diameter. On the right is presented a face view of the investing membrane and the underlying monadigerous mass. On the left the focus is so adapted as to be fixed on a face-view of the monad-mass and at the same time on a sectional profile of the investing membrane at a^1, b^2, *c* and *d*.

Fig. 2. Magnified 780 diameters. Interior of a monad-chamber, seen through the aperture; the monads appear in end view, and crowded together side by side like a pavement work.

Fig. 3. Magnified 1,600 diameters. A single monad, as seen in profile in the monad-chamber. Only two contractile vesicles were present in this specimen. The cylindrical collar (*k*) is extended to its utmost.

Fig. 3*a*. Magnified 1,600 diameters. Foreshortened, front view of a monad; the body (*j*) in the distance; the hollow cylinder (*k*) projecting toward the observer like a dark hoop, and the *flagellum* (*l*) in the center appearing as a black spot.

Fig. 4. Magnified 780 diameters. Sectional view of a monad-chamber, bringing the aperture (*i*) into profile, as well as the monads which lie at the same level; thus showing their convergence about the central open space.

ART. LV.—*Description of a Printing Chronograph*; by G. W. HOUGH, Director of the Dudley Observatory.

ABOUT the year 1848, the idea of recording astronomical observations, by the use of galvanic electricity, was put in successful operation by different individuals. Since that time chronographs of various forms have been constructed for recording in a legible manner, on a moving sheet of paper, the time of any phenomenon observed. The great superiority, in point of accuracy and saving of labor, over the old eye and ear method, formerly used, led to the almost general adoption of the new plan.

During the past ten years the idea of constructing a chronograph, which should print with type the time of the observation, has been entertained by a number of persons. About five years since Prof. Hilgard of the Coast Survey, read a description

f an apparatus designed for this purpose, and about the same
me Prof. C. A. Young, of Dartmouth College, published a
roposed plan for one,[*] But, so far as we are informed, the
echanical construction of such an apparatus has not hereto-
re been attempted by any one.

The construction of a machine which shall carry a type
heel, capable of giving impressions, with uniform velocity for
number of hours together, without sensible variation in its
otion, is a problem which is not easy of solution.

Some five or six years ago, in a paper read before the Albany
stitute, I gave an account of the method I proposed to adopt,
d in the construction of the machine, now to be described,
e plan then proposed has been generally followed. My plan,
hich is radically different from any other proposed, is based
the principle of using separate systems of mechanism for
e fast-moving type wheel, and those recording the integer
inutes and seconds, regulating each with electro-magnets
ntrolled by the standard clock.

For a clear understanding of the mechanism, elaborate draw-
gs would be necessary. We shall, therefore, merely give a
neral account of its construction and peculiarities:

1st. A system of clock-work carrying a type wheel, with
ty numbers on its rim, revolving once every second: one,
o, or parts of two numbers being always printed, so that
ndredths of seconds may be indicated. This train is pri-
arily regulated to move uniformly by the Frauenhofer fric-
n balls, and secondarily by an electro-magnet acting on the
t-moving type wheel, and controlled by the standard clock.
is train is entirely independent, and can be stopped at pleas-
e, without intefering with the other type wheels.

2nd. A system of clock-work, consisting of two or more
afts, carrying the type wheels indicating the minutes and
onds. The motion of this train is also governed by an elec-
-magnet, controlled by the standard clock, operating an es-
ement, in a manner analogous to the action of an ordinary
ck; every motion of the escapement advancing the type one
mber.

There are three type wheels, indicating minutes, seconds and
ndredths of seconds. The integer seconds are advanced at
ry oscillation of the standard pendulum; and the minute, at
end of each complete revolution of the seconds wheel.

The type wheels are constructed of brass disks, around the
umference of which is soldered a strip of electrotype copper,
ding sixty numbers.

Presuming now we have this system of type wheels in opera-
. it is necessary to print without disturbing their motion;

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[*] See this Journal, No. 124, July, 1866.

especially is this true for the fast-moving type wheel. Aft long series of experiments, during which the fast mov wheel was detached and stopped in various ways, we fir made the impression from the spring of the hammer only. allowing the blow to fall directly on the type, but arresting about half an inch before it reached the top of the type. this device, which is regarded of the greatest importance motion of the type is not disturbed an appreciable amou Any number of impressions following each other in rapid cession, does not disturb the fast-moving wheel the one hu dredth of a second. By this plan, none of the type wheels stopped or locked in the act of printing, and records of obser tions may follow each other as fast as the hammer can be ma to deliver the blow.

If the record is made while the type wheel indicating integ seconds is in the act of escaping, two numbers, or one numbe and part of another, is printed, so there is never any ambig uity about the record; this condition, of course, only occur when the fast moving wheel indicates 0·95ˢ to 0·00ˢ. If two numbers are printed when, for example, the hundredths read 98, the smaller of the integer seconds is the correct one. The time required for the action of the escapement is about 0·06 sec.

The blow for printing may be struck directly, by means of a strong electro-magnet; but the cost and trouble of keeping up a large battery for this purpose led us to do all the work mechanically, only using electricity as the governing power. Accordingly, a heavy running gear was built for raising the hammer, capable in its present form of delivering 2000 blows without rewinding; and it can be readily modified to give five times that number, if desirable. This gearing is entirely detached from the hammer when elevated, but is unlocked just before the hammer reaches the type, immediately raising it again. The time consumed for this operation is about three-tenths of a second, allowing, therefore, observations to follow each other at a minimum interval of one half second. When the hammer is elevated it is locked by an electro-magnet, the operation of this magnet allowing it to fall and print. The armature time of the hammer is about 0·07 sec., being but little in excess of our ordinary chronographic recording pen; and since the hammer is acted on by gravity alone, the armature time will be sensibly uniform.

The types are inked by means of small rollers, covered with cloth, resting against their rim, and revolving with the wheel by friction. These rollers require inking every two or three days. If desirable, the inking rollers may be dispensed with, and impression paper used instead. After numerous experiments made with both methods, we have preferred the ink.

The paper fillet, two inches in width, is wound on a small ool, holding about 60 feet, and drawn between two rollers, e same as a Morse Register. Every time the hammer falls, e fillet is advanced about one-quarter of an inch, by the acon of an escapement driven by a weight. One spool of paper ill hold about 1200 observations, including the spacing for fferent objects. This same escapement is also operated by an ectro-magnet, under the control of the observer, who, by ressing a key, is able to make spaces of any width between the rints.

The train carrying the minutes and integer seconds will run ight hours; the gear for elevating the hammer will deliver 000 blows; and the train for moving the paper fillet will go 200 times without winding. The fast moving train runs one our and thirty-six minutes; but since this train can be stopped t pleasure, without changing the zero of the type, its comparaively brief running is not a serious inconvenience.

To recapitulate, we claim the following:

1st, Separate movements for the integer seconds and the undredths of seconds; 2nd, The method of regulating the hundredths of seconds wheel by an electro-magnet in connection with the standard clock; 3rd, The method of printing double or single numbers without stopping the type wheels; 4th, The method of striking the blow indirectly, using the spring of the hammer; 5th, The method of elevating and locking the hammer. The minor details for paying off the paper fillet, etc., may be accomplished in various ways.

The battery power required is about the same as for an ordinary chronograph. Three Grove elements, or six Hill's elements, work the two electro-magnets well. A separate battery of about the same size is used for the hammer and fillet magnets.

In point of accuracy, this machine leaves nothing to be desired, and is much beyond what we thought possible. From a vast number of experiments, made by recording automatically the beats of the standard clock, both at the middle and end of the oscillation, the mean error for a single print is found to be about 0·013 sec., equal in this respect to the recording chronograph. The maximum difference in the records of the beats seldom exceeds 0·03 sec.; and we believe this is as much due to the irregularity in the clock connection as in the running of the machine, since the same thing is found in ordinary chronograph records, where the measures are made from second to second.

During the building of the machine, which was accomplished by my assistant, Mr. Foreman, and myself, the past winter, as we could find the time, a great many experiments were tried in the method of regulation, printing, etc. The fast mo train was used to propel the integer seconds and minute wheels, dispensing with the auxiliary movement; but the turbance of its motion was considerable, especially at the of every minute, when it had double duty to perform.

The saving of time and labor by the use of a printing chro graph is very considerable. At the lowest estimate, it work equivalent to the labor of one person where three are ployed at the same time. In our zone work in former ye when the zone extended two hours in right ascension, it usu required the labor of two persons a whole day to convert chronographic records into numbers and copy them on blank forms. With the observations printed, this labor wholly dispensed with; since the "mean" is at once dedu from the printed records.

The machine is readily adjusted to indicate the same bers as the clock's face, the type being so set as to print hundredths when the pendulum is at its lowest point, where magnetic circuit is completed. In the construction of the ap ratus, provision was made for attaching engraved rings to type wheel shaft, showing at a glance the time. But these not found essential, as they would but little facilitate the ting of the type, which is accomplished as follows: The ute type wheel, which is free to move in either direction revolved to correspond to the correct minute; an impress may then be taken, and the machine started, when the clo indicates the same; the seconds being readily counted from beats of the magnet regulating the fast moving train. whole time for this adjustment need never exceed two min

In the observation of zone stars, the type may be set to the integer-seconds of mean right ascension, so that the reduction will always be a small quantity.

The constant use of this mechanism on every day and obs ing night, for more than four months, during which time than ten-thousand records have been made, enables us to sp with confidence of its success, both as regards correctness printing and in saving of labor.

Other things being equal, it is found, that for three observ twice as many observations can be reduced in the same time when a recording chronograph is employed.

ART. LVI.—*Longitude Determination across the Continent;* by GEORGE W. DEAN. (Read before the American Association at Indianapolis.)

WITH the permission of Professor Peirce, Superintendent of he United States Coast Survey, I offer to the Association a brief statement, in regard to the method used, and the results obtained, by the Coast Survey, in determining the longitude of San Francisco and several intermediate points, by telegraphic exchange of clock signals, with Harvard College Observatory, Cambridge, Massachusetts.

In November, 1862, I was requested by the late Prof. Bache to obtain such information as might be practicable in regard to the construction of the telegraph lines across the Continent with the view of determining, by the telegraphic method, the difference of longitude between the Atlantic and Pacific coasts. He at the same time requested me to make a series of experiments with "relay magnets," generally known as "*telegraph repeaters*," for the purpose of measuring approximately the time required for transmitting a signal through one or more of those instruments. The results of those preliminary experiments were inserted by the Professor in the Appendix to his annual report for 1863, and the final results in his report for the year 1864.

I was greatly indebted to the present distinguished Secretary of the Smithsonian Institution, Professor Henry, for the success attending the experiments with "relay magnets" in 1863–64; and it is gratifying that the results then obtained have, in some degree, aided in modifying and improving the construction of the telegraph instruments now in general use in the United States. In October, 1868, I was directed by the Superintendent, Professor Peirce, to make the requisite arrangements for determining, by telegraphic exchange of clock signals, the difference of longitude between Harvard College Observatory and one of the Coast Survey stations on the Pacific coast, and to prepare a programme for conducting the operations.

The general outline of the plan was to establish an astronomical station at Omaha, Nebraska, which is, by the telegraph route, about 1550 miles from Cambridge. Also a station at Salt Lake City, Utah, which is located about 1050 miles west of Omaha, and 950 miles east of San Francisco. Professor Winlock, Director of Harvard College Observatory, coöperated with the Coast Survey, by placing his astronomical instruments at the service of the Superintendent and directing the telegraphic longitude operations at Cambridge.

The observations for determining the clock and instrumental corrections at Cambridge, were made chiefly by Assistant A. T. Mosman and Sub-Assistant F. Blake, Jr.

At Omaha, the clock and instrumental corrections were determined by Assistant Edward Goodfellow and Mr. E. P. Austin, who used a forty-six-inch transit with an aperture of two and three-fourths inches. All the observations were recorded by an astronomical clock in connection with a chronograph register. At Salt Lake City, the clock and instrumental corrections were determined by myself, assisted by Mr. F. H. Agnew, Sub-Assistant in the Coast Survey.

The instruments used were similar to those provided for the stations at Omaha and San Francisco.

Assistant George Davidson had charge of the longitude operations at San Francisco, and coöperated with Professor Winlock and myself in making the telegraphic longitude determinations across the Continent.

Cold dry weather being most favorable for exchanging telegraph signals between distant stations, arrangements were made for these experiments during the winter of 1868–69.

Whenever the weather permitted, the clock and instrumental corrections at each station were carefully determined, immediately before and after the exchange of clock signals between the several stations.

For this purpose a series of eight or ten standard zenith and two or three circumpolar stars were observed, one-half with the lamp-end of the axis *east*, and an equal number with the lamp *west*. In such a series, the probable error of the result for clock correction in no case exceeded 0·05 seconds. Mayer's formulæ, by application of the method of least squares, have been used in these reductions, which have been made in the most satisfactory manner by Captain Isaac Bradford of Cambridge.

The formulæ and a single example, for the purpose of illustrating the general arrangement of the reductions, are given with the abstract of longitude results.

In closing this paper, I will state, that on the nights of February 28th and March 7th, 1869, the Western Union Telegraph Company, with their usual liberality for the advancement of science, placed two of their telegraph lines, between Cambridge and San Francisco, at the service of the Coast Survey, for the purpose of measuring the "transmission time" of signals sent from Cambridge to San Francisco and returned, and "*vice versa.*"

The entire length of the several circuits, which were composed chiefly of No. 9 iron wire, was about 7200 miles, and the number of "*telegraph repeaters*" used was thirteen.

The results were very satisfactory, and accorded closely with the "double transmission time" deduced from the longitude determinations between Cambridge and San Francisco, and also with the results of the experiments made for "transmission time" with a single wire between those points, by Professor Winlock and Assistant Davidson.

Formulæ used in the Reductions.

Star. ampTallies α. δ.	
M.	Mean of Tallies.
F.	Mean of Thread Intervals.
log F.	
og sec δ.	
log ρ.	ρ is the correction for rate, and its log. is 0·000005 for a gain of 1 second daily: 0·00119 for a mean time clock.
log σ.	σ is the sine correction: log σ being additive to log F; when F sec δ is less than 2^m, it may be neglected.
log R.	
R.	R = F sec δσρ; and is to be added to M to obtain the Time of Transit over the mean of all the threads.
b_0.	b_0 = the level correction in time, corrected for inequality of pivots: it is positive for west end high.
A.	$A = \frac{\sin(\varphi-\delta)}{\cos\delta}$
B.	$B = \frac{\cos(\varphi-\delta)}{\cos\delta}$ 180° − δ being used instead of δ when the star is below the pole.
C.	$C = \sec\delta$
κ.	κ = the diurnal aberration = sec 0·021 cos φ sec δ. It is (−) in upper and (+) in lower culminations.
Bb_0.	
T.	$T = M + R$.
t.	$t = T + Bb_0 + \kappa$.
ω.	$\omega = \alpha - t = \Delta t + Aa \pm Cc$.
Cc.	
ω_0.	$\omega_0 = \omega \pm Cc$, upper sign for lamp west.

The collimation constant (*c*) is determined from reversals on circumpolar stars, and is to be obtained from the equation

$$t_e - t_w = \omega_w - \omega_e = 2Cc.$$

A is positive except for stars between the zenith and north pole.
B " " " at lower culmination.
C " " " " "

The local time and azimuth are obtained thus: assume an approximate value of the clock correction $=\theta$ for an arbitrary time T_0, and call $w - \theta = w'$; if the collimation is known and the corresponding correction applied, we have only to reduce the value of ω_0 for the several stars to the time T_0 by applying the correction for daily rate. Thus:—

$$(\omega_0) = \omega_0 + \frac{t - T_0}{24 \text{ hr.}} \times \text{daily rate},$$

and we have, putting $\Delta\theta = \Delta t - \theta$,

$$\Sigma\Delta\theta + \Sigma Aa = \Sigma\omega'_0$$
$$\Sigma A\Delta\theta + \Sigma A^2 a = \Sigma A\omega'_0.$$

Whence we determine *a*, $\Delta\theta$, and thence Δt for the time T_0.

Reductions of the Observations for Clock and Instrumental Corrections.—February 17, 1869.

$c = +·012$; hourly rate $= +·005$.

Star.	ω Draconis, L. C.		ψ′ Draconis (pr), L. C.		α Orionis.	ζ Geminor.	ε Can. Maj.	δ Can. Maj.	δ Geminor.	α Can. Min.	β Geminor.	φ Geminor.
Lamp	W.	E.	E.	W.	W.	W.	W.	W.	W.	E.	E.	E.
Tallies.	F. C.	E. F.	B. C.	C. B.	C. D. E.	C. D. E.	C. D. E.	C. D. E.	D.	E. D. C.	E. D. C.	E. D. C.
α	hs. min. 5 37	s. 41·56	hs. min. 5 44	s. 14·35	hs. min. sec. 5 48 5·20	hs. min. sec. 6 30 9·21	hs. min. sec. 6 53 29·63	hs. min. sec. 7 3 4·87	hs. min. sec. 7 12 18·60	hs. min. sec. 7 32 27·46	hs. min. sec. 7 37 18·63	hs. min. sec. 7 45 29·50
δ	+68° 48′	52″·0	+72° 12′	32″·9	+7° 22′ 37″·5	+16° 30′ 22″·4	−28° 48′ 2″·2	−26° 11′ 29″·3	+22° 14′ 8″·4	+5° 33′ 19″·2	+28° 20′ 18″·6	+27° 6′ 2″·0
M	h. m. s. 5 36 24·346	h. m. s. 5 38 34·368	h. m. s. 5 42 49·900	h. m. s. 5 45 19·295	h. m. s. 5 47 52·714	h. m. s. 6 29 56·682	h. m. s. 6 53 17·152	h. m. s. 7 2 52·422	h. m. s. 7 12 6·104	h. m. s. 7 32 14·944	h. m. s. 7 37 6·096	h. m. s. 7 45 16·975
F	+23·499	−23·499	+22·083	−23·519	+0·024	+0·024	+0·024	+0·024	0·000	−0·024	−0·024	−0·024
log F	1·37105	1·37105$_n$	1·344058	1·37142$_n$	8·38021	8·38021	8·38021	8·38021	−∞	8·38021	8·38021	8·38021
sec δ	0·442024	0.442024	0·514927	0·514927	0·00361	0·01829	0·05735	0·04705	0·03351	0·00205	0·05544	0·05051
log o log σ			·02	·02								
log R	1·813074	1·813074$_n$	1·858987	1·886349$_n$	8·38382	8·39849	8·43756	8·42726	−∞	8·38226$_n$	8·43565$_n$	8·43072$_n$
R	+15·024	−15·024	+112·275	−116·975	+·024	+·025	+·027	+·027		−·024	−·027	−·027
b_0	+0·94	+·066	−·066	+·054	+·054	+·061	+·004	+·010	+·024	+·080	+·076	+·074
A	+2.	580	+2.	976	+·578	+·455	+1·080	+1·037	+0·372	+0·602	+0·276	+0·296
B	−1.	000	−1.	362	+·826	+·938	+0·368	+0·407	+1·014	+0·804	+1·102	+1·084
C	−2.	767	−3.	273	+1·008	+1·043	+1·141	+1·114	+1·080	+1·005	+1·136	+1·123
κ	+·043	+·043	+·051	+·051	−·016	−·016	−·018	−·017	−·017	−·016	−·018	−·017
Bb_0	−·094	−·066	−·090	−·074	+·045	+·057	+·002	+·004	+·024	+·064	+·084	+·080
T	5 37 29·370	5 37 29·344	5 44 2·175	5 44 2·320	5 47 52·738	6 29 56·707	6 53 17·179	7 2 52·449	7 12 6·104	7 32 14·920	7 37 6·069	7 45 16·948
t	5 37 29·319	5 37 29·321	5 44 2·136	5 44 2·297	5 47 52·767	6 29 56·748	6 53 17·163	7 2 52·436	7 12 6·111	7 32 14·968	7 37 6·135	7 45 17·011
ω	+12·241	+12·239	+12 214	+12·053	+12·433	+12·462	+12·467	+12·434	+12·489	+12·492	+12·495	+12·489
Cc					−·012	−0·13	−·014	−·013	−·013	+·012	+·014	+·013
ω_0	+12.	240	+12.	134	+12·421	+12·449	+12·458	+12·421	+12·476	+12·504	+12·509	+12·502
(ω_0)	+12.	246	+12.	130	+12·420	+12·450	+12·452	+12·410	+12·474	[illegible]	[illegible]	[illegible]

February 17, 1869.—*Collimation.*

Star.	Time.	Cc.	C.	*c.*
	h. m.			
ω Draconis L. C.	5 37	+·001	−2·767	−·0004
ψ' Draconis L. C.	5 44	−·0805	−3·273	+·0246

$_0 = 6h.\ 46m.$ $\theta = +12\cdot550$.

Clock and Azimuth Corrections.—Observer A. T. M.

Star.	Lamp.	(ω_0)	A	ω'_0	A^2	$A\omega'_0$	Aa	Δt
onis L. C.	W. E.	+12·246	+2·580	−·304	6·656	−0·784	−·312	12·558
onis (pr) L. C.	E. W.	+12·139	+2·976	−·411	8·857	−1·223	−·360	12·499
nis,	W.	+12·426	+0·578	−·124	·335	−0·072	−·070	12·496
inor,	W.	+12·450	+0·455	−·100	·207	−0·046	−·055	12·505
Maj.	W.	+12·452	+1·080	−·098	1·167	−0·106	−·131	12·583
Maj.	W.	+12·420	+1·037	−·130	1·076	−0·135	−·125	12·545
inor,	W.	+12·474	+0·372	−·076	·139	−0·028	−·045	12·518
Min.	E.	+12·500	+0·602	−·050	·363	−0·030	−·073	12·573
inor,	E.	+12·505	+0·276	−·045	·076	−0·012	−·033	12·538
inor,	E.	+12 497	+0·296	−·053	·088	−0·016	−·036	12·533
			+10·252	−1·391	18·964	−2·452	+	12·535

$10\ \Delta\theta + 10\cdot252\ a = -1\cdot391$

$+10\cdot252\ \Delta\theta + 18\cdot964\ a = -2\cdot452$

$\Delta\theta + 1\cdot0252\ a = -0\cdot1391$

$+10\cdot251\ \Delta\theta + 10\cdot510\ a = -1\cdot426$

$+ 8\cdot454\ a = -1\cdot026$

$a = -0\cdot121$

$\Delta\theta - \cdot1240 = -\cdot1391$

$\Delta\theta = -\cdot015$

$\Delta t = +12\cdot535 \pm \cdot007$

Longitude between Cambridge and Omaha.

[Not corrected for personal equation.]

Date 1869.	$\lambda + \chi_2$ h. m. s.	$\lambda + \chi_2$ Probable error.	No. of Series of Signals.	$\lambda - \chi_1$ h. m. s.	$\lambda - \chi_1$ Probable error.	No. of Series of Signals.
Feb. 17,	1 39 15·305	±·018	2	1 39 14·990	±·015	3
" 18,	15·293	±·033	2	14·960	±·030	2
" 24,	15 278	±·028	3	14·999	±·032	2
" 25,	15·351	±·015	2	15·009	±·015	2
" 27,	15·351	±·031	1	15·007	±·015	4
" 28,	15·384	±·034	1	14·982	±·033	1
Mean						

Date 1869.	2λ h. m. s.	2λ Probable error.	λ h. m. s.	λ Probable error.	$\chi_1 + \chi_2$ Double transmission time.
Feb. 17	3 18 30·295	±·023	1 39 15·147	±·012	0s·315
" 18	30·253	± 045	15·127	±·022	0·333
" 24	30·277	±·043	15·138	±·021	0·279
" 25	30·360	±·021	15·180	±·011	0·342
" 27	30·358	±·034	15·179	±·017	0·344
" 28	30·366	±·047	15·183	±·024	0·402
Mean			1 39 15·159	±·008	0·366

NOTE.—Telegraph repeaters were used at Buffalo and Chicago.
Length of telegraph wires in circuit between Cambridge and Buffalo, 504 miles;
iffalo and Chicago, 540 miles; Chicago and Omaha, 498 miles.

Longitude between Cambridge and Salt Lake City.—Not corrected for personal equation.

Date 1869.	$\lambda - \chi_2$		No. of Series of Signals.	$\lambda - \chi_1$		No. of Series of Signals.	2λ		λ		$\chi_1 + \chi_2$
	h. m. s.	Probable error.		h. m. s.	Probable error.		h. m. s.	Probable error.	h. m. s.	Probable error.	Double transmission time.
Feb. 17	2 43 4·497	±·042	1	2 43 3·966	±·030	2	5 26 8·463	±·052	2 43 4·232	±·026	0s·531
" 18	4·609	±·025	2	3·986	±·025	2	8·595	±·035	4·297	±·018	0·623
" 19	4·576	±·022	--	3·985	±·012	3	8·561	±·025	4·280	±·013	----
" 24	4·487	±·035	1	3·982	±·033	2	8·469	±·048	4·235	±·024	0·505
" 25	4·596	±·029	2	3·989	±·028	2	8·585	±·040	4·293	±·020	0·607
" 27	4·563	±·030	2	3·908	±·035	3	8·471	±·046	4·236	±·023	0·655
" 28	4·501	±·041	1	3·827	±·029	2	8·328	±·050	4·164	±·025	0·674
Mar. 3	4·588	±·054	1	4·048	±·040	2	8·636	±·067	4·318	±·034	0·540
Mean									2 43 4·257	±·008	0·591

Note.—Telegraph repeaters were used at Buffalo, Chicago, Omaha and Cheyenne.
The length of telegraph wire in the circuit between Cambridge and Salt Lake City was 2583 miles.

Longitude between Cambridge and San Francisco.—Not corrected for personal equation.

Date 1869.	$\lambda + \chi_2$		No. of Series of Signals.	$\lambda - \chi_1$		No. of Series of Signals.	2λ		λ		$\chi_1 + \chi_2$
	h. m. s.	Probable error.		h. m. s.	Probable error.		h. m. s.	Probable error.	h. m. s.	Probable error.	Double transmission time.
Feb. 17	3 25 7·706	±·020	2	3 25 6·917	±·020	2	6 50 14·623	±·028	3 25 7·311	±·014	0s·789
" 18	7·715	±·018	4	6·834	±·031	1	14·549	±·036	7·275	±·018	0·881
" 24	7·629	±·027	2	6·843	±·038	1	14·472	±·047	7·236	±·023	0·786
" 25	7·718	±·024	1	6·865	±·024	1	14·583	±·034	7·292	±·017	0·853
" 27	7·728	±·035	1	6·907	±·023	2	14·635	±·042	7·317	±·021	0·821
" 28	7·615	±·027	2	6·693	±·034	1	14·308	±·044	7·154	±·022	0·922
Mar. 3	7·635	±·042	1	6·859	±·047	1	14·494	±·064	7·247	±·032	0·776
" 5	7·633	±·029	1	6·823	±·029	1	14·456	± 042	7·228	±·021	0·810
" 7	7·637	±·022	2	6 923	±·028	1	14·560	±·036	7·280	±·018	0·714
Mean									3 25 7·260	±·007	0·817

Note.—Telegraph repeaters were used at Buffalo, Chicago, Omaha, Cheyenne, Salt Lake City, and Virginia City.
The length of telegraph wire in the circuit between

gitude Determinations across the Continent, January and February, 1869. (Final results.)

Personal Equations.

Dean − Mosman = +0^{s}·11	From Gould's Report of May, 1867, p. 75.	
dfellow − Dean = +0·02		
Dean − Davidson = +0·180	From observations made at San Francisco, April, 1869.	

Station.	**Observer.**	**Dean's Standard.**	
Cambridge,	Mosman,	+0^{s}·110	To be applied to the clock corrections of the respective stations to reduce them to Dean's standard.
Omaha,	Goodfellow,	−0·020	
Salt Lake,	Dean,	0·000	
San Francisco,	Davidson,	+0·180	

o correct the differences of longitude for personal equation, have:—

Cambridge Time	—	Omaha Time	= +0^{s}·130
" "	—	Salt Lake Time	= +0·110
Omaha "	—	" "	= −0·020
Cambridge "	—	San Francisco Time	= −0·070
Omaha "	—	" "	= −0·200
Salt Lake "	—	" "	= −0·180

STATIONS.	Difference of Long. (λ).	Personal equation.	Corrected difference of Longitude.	Double transmission time.
	h. m. s.	s.	h. m. s. s.	s. s.
bridge to Omaha	1 39 15·159	+·130	1 39 15·289 ± ·008	·336 ± ·015
bridge to Salt Lake	2 43 4·257	+·110	2 43 4·367 ± ·008	·591 ± ·019
ha to Salt Lake	1 3 49·081	—·020	1 3 49·061 ± ·008	·260 ± ·016
br'ge to S. Francisco	3 25 7·260	— 070	3 25 7·190 ± ·007	·817 ± ·014
ha to San Francisco	1 45 52·094	—·200	1 45 51·894 ± ·010	·483 ± ·023
Lake to S. Francisco	0 42 3·024	—·180	0 42 2·844 ± ·008	·242 ± ·016

STATIONS.	Difference of Longitude.	$\chi_1 + \chi_2$
	h. m. s. s.	s. s.
ridge to Omaha,	1 39 15·289 ± ·008	·336 ± ·015
a to Salt Lake,	1 3 49·061 ± ·008	·260 ± ·016
ridge to Salt Lake (sum),	2 43 4·350 ± ·011	·596 ± ·022
" (direct),	2 43 4·367 ± ·008	·591 ± ·019
Difference,	·017 ± ·014	·005 ± ·029
ridge to Omaha,	1 39 15·289 ± ·008	·336 ± ·015
a to Salt Lake,	1 3 49·061 ± ·008	·260 ± ·016
ake to San Francisco,	0 42 2·844 ± ·008	·242 ± ·016
ridge to San Francisco (sum),	3 25 7·194 ± ·014	·838 ± ·027
" (direct),	3 25 7·190 ± ·007	·817 ± ·014
Difference,	·004 ± ·016	·021 ± ·030
a to Salt Lake,	1 3 49·061 ± ·008	·260 ± ·016
ake to San Francisco,	0 42 2·844 ± ·008	·242 ± ·016
a to San Francisco (sum),	1 45 51·905 ± ·011	·502 ± ·023
" (direct),	1 45 51·894 ± ·010	·483 ± ·023
Difference,	·011 ± ·015	·019 ± ·032
ridge to Omaha,	1 39 15·289 ± ·008	·336 ± ·015
a to San Francisco,	1 45 51·894 ± ·010	·483 ± ·023
ridge to San Francisco (sum),	3 25 7·183 ± ·013	·819 ± ·027
" (direct),	3 25 7·190 ± ·007	·817 ± ·014
Difference,	·007 ± ·015	·002 ± ·030

STATIONS.	Difference of Longitude.	λ
	h. m. s. s.	*s.*
Cambridge to Salt Lake,	2 43 4·367 ± ·008	·591±1
Salt Lake to San Francisco,	0 42 2.844 ± ·008	·24[illegible]±1
Cambridge to San Francisco (sum),	3 25 7·211 ± ·011	·833±1
" " (direct),	3 25 7·190 ± ·007	·817±1
Difference,	·021 ± ·013	·016±1
Cambridge to San Francisco,	3 25 7.190 ± ·007	·817±1
(C. to O.)+(O. to S. L.)+(S. L. to S. F.)	7·194 ± ·014	·838±
(C. to O.)+(O. to S. F.)	7·183 ± ·013	·819±1
(C. to S. L.)+(S. L. to S. F.)	7 211 ± ·011	·833±1
Cambridge to San Francisco (Mean of all),	3 25 7·194 ± ·006	·827±1

ART. LVII.—*Notice of the Invertebrata dredged in Lake Supe in 1871, by the U. S. Lake Survey, under the direction of b C. B. Comstock, S. I. Smith, naturalist;* by S. I. SMITH A. E. VERRILL.

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DURING the explorations in Lake Superior, mentioned in last number of this Journal (page 373) the following spe were obtained, together with a number of minute forms, wh have not been determined.

A full account of the expedition, with descriptions of t species collected, will be published in the official report of t expedition.

RADIATA.

Hydra carnea Agassiz. A beautiful *Hydra*, agreeing wi Ayer's description of this species, was very abundant at t eastern end of St. Ignace, upon rocks along the shore and ne the surface, frequently completely covering quite large surfa where they were protected from the direct sunlight, and w also brought up in many of the dredgings from 8 to 148 fathom In 32 fathoms, Neepigon Bay, and in 59 fathoms, off Simmo Harbor, it was brought up in abundance from a soft clayey bo tom. In the deep dredgings, it frequently came up near t bottom of the clay in the dredge, and was evidently not caug while the dredge was near the surface.

MOLLUSCA.

Limnæa. A species allied to *L. disidiosa* Say, was abunda among *Cladophora* in 8 to 13 fathoms on the south side of S Ignace Island.

Physa heterostropha Say. In the cove at the eastern end o St. Ignace, in 4 to 6 fathoms, and young specimens, in 8 to 1 fathoms, at the locality with the *Limnæa* just mentioned.

Physa vinosa Gould. A very young specimen, apparently o this species, in 6 to 8 fathoms among the Slate Islands.

lanorbis parvus Say. Common in 8 to 13 fathoms on the th side of St. Ignace.

alvatu sincera (Say sp.). Abundant with the last species, 3 to 13 fathoms, and also, in 4 to 6 fathoms, in the cove at eastern end of the same island.

phærium sp. nov.? Among the Slate Islands, in 6 to 8 oms. A single young specimen of another species of *Sphæ-n* was found, in 8 to 13 fathoms, on the south side of St. ace.

isidium Virginicum Bourguignat. On the south side of St. ace, 8 to 13 fathoms.

isidium abditum Haldeman. With the last species, in 8 to fathoms, and also, in 4 to 6 fathoms, in the cove at the ern end of the same island.

isidium compressum Prime. In the cove at the eastern end t. Ignace, 4 to 6 fathoms.

isidium sp. nov. A small, semi-translucent species, the same ound by Dr. Stimpson in Lake Michigan, was brought up early every dredging. It was common in the cove at the ern end of St. Ignace, on sandy and muddy bottom, in 4 to thoms, and abundant among *Cladophora*, in 8 to 13 fathoms, he south side of that island; among the Slate Islands, in 6 and 12 to 14 fathoms; at 13 to 15 fathoms on a sandy om in Simmon's Harbor; near Copper Harbor, in 17 fathoms, sand; in 32 fathoms, very soft clayey mud, in Neepigon ; off Copper Harbor, in 62 fathoms, and north of Keweenaw t, in 82 fathoms, soft reddish clayey mud and sand; and l the deep dredging down to 159 fathoms.

WORMS.

umbricus lacustris Verrill, sp. nov. About 1·5 inches long, in diameter. Body round, distinctly annulated. Head t, conical, obtusely pointed. Setæ spine-like, strongly ed, acute, arranged two by two, those of each pair close ther. Color reddish brown.

uth side of St. Ignace, among *Cladophora*, 8 to 13 fathoms.

enuris abyssicola Verrill, sp. nov. Worm slender, attenuated eriorly, about ·30 of an inch long, ·03 in diameter anteriorly. composed of about 28 segments, those of the posterior elongated; those of the anterior half shorter, separated by t constrictions. Cephalic lobe short, subconical, rounded ont. Mouth large, semi-circular. Intestine slender, monili-, containing sand. Anus terminal, with three or four slight . Setæ in four, fan-shaped fascicles on each segment, com-ing at second segment behind the mouth. The two al fascicles are separated by a space equal to about twice ength of the setæ, of which there are five or six in each le; the satæ are simple, acute, slightly curved, equal to about one-sixth the diameter of the body. The lateral fascicles contain three to five somewhat shorter and straighter setæ. One specimen appeared to have four minute ocelli on the upper side of the head.

Off Copper Harbor, 17 fathoms, sand; off Simmon's Harbor, 60 fathoms; and on the line from the Slate Islands to Stannard Rock, fourth haul, 159 fathoms.

Sænuris limicola Verrill, sp. nov. Worm more slender than the preceding, attenuated posteriorly, composed of about segments. Length about ·33 of an inch, diameter ·02. Cephalic lobe blunt, conical. Setæ in four fascicles upon each segment, six to eight in each fascicle anteriorly, four or five posteriorly. The setæ in all the fascicles are relatively long, slender, curved and acute. Two tortuous red blood vessels pass along the intestine, forming a loop at each segment. Intestine moniliform.

On the line between the Slate Islands and Stannard Rock, fourth haul, 159 fathoms.

Chirodrillus, gen. nov. Allied to *Sænuris*, but with six fan-shaped fascicles of setæ upon each segment, two of which are ventral, two lateral, and two sub-dorsal; setæ in the ventral and lateral fascicles four to nine, simple, acute, slender, curved like an italic *f*; those of the dorsal fascicles, stouter and less curved, three to six in each fascicle. Intestine wide, somewhat moniliform. Anus terminal, large.

Chirodrillus larviformis Verrill, sp. nov. Body rather short and not very slender, cylindrical, obtuse at both ends, distinctly annulated, composed of about 38 rings. Length about ·30 of an inch; diameter ·05. Cephalic lobe short, conical, obtuse; mouth large, semi-circular beneath. Ventral fascicles of setæ near together, with about five setæ, which are rather short, simple, acute, little curved; lateral fascicles with five or six setæ of similar form and size; sub-dorsal ones similar. When preserved in alcohol, the body is usually curved ventrally or in a simple coil. Color, when living, translucent whitish, intestine slightly greenish. A thickened smooth zone commences behind the 10th setigerous ring, occupying the space of about four segments.

Off Copper Harbor, 17 fathoms, sand; off Simmon's Harbor, 59 fathoms, clayey mud.

Chirodrillus abyssorum Verrill, sp. nov. Sub-cylindrical, thicker anteriorly, distinctly annulated, composed of about 43 segments. Length ·25 of an inch; diameter about ·02. Cephalic lobe short, conical, obtuse, mouth large, semi-circular. Ventral fascicles with eight or nine setæ anteriorly, five or six posteriorly. The setæ are long, slender, acute, strongly curved, those on the inferior side of the fascicles nearly twice as long as those of the upper side; setæ of the lateral fascicles five or six, slender, nearly as long as those of the ventral ones, and similar in form;

sal fascicles with four or five shorter, stouter, and straighter,
te setæ.

Six miles S.E. of Passage Island, 47 fathoms; on line from the
te Islands toward Stannard Rock, fourth haul, 159 fathoms.

ubifex profundicola Verrill, sp. nov. A rather stout species
the genus, about 1 to 1·5 inches long, ·05 in diameter an-
orly, more slender posteriorly (·02 in diameter). Cephalic
e short, conical; one specimen apparently had two minute
lli. Mouth large, semi-circular. Intestine moniliform, with
simple red blood-vessels running along its whole length
uniting at the constrictions. In the first five or six seg-
nts there are slender vessels of nearly uniform size, which
n lateral loops in each segment. Anus terminal, wide, with
ut ten small lobes. Setæ in four fascicles upon each seg-
t. Those of the lateral fascicles three anteriorly, often but
short, slightly curved, mostly with minute forked and
ked tips; those of the ventral series in fascicles of four to
three or four times longer than the upper ones, considerably
, the ends minutely hooked and forked.

eepigon Bay, 32 fathoms.

ephelis fervida Verrill, sp. nov. Leech two or three inches
, ·20 to ·30 wide, elongated and slender in full extension,
little depressed, most so posteriorly, often round and
ring anteriorly. Mouth large, nearly circular, subterminal,
upper lip, in contraction, short and rounded; corrugated
in the œsophagus with three conspicuous folds, eyes eight,
kish, conspicuous, two pairs, a little apart, on the first ring
e head; two pairs wider apart and farther back on the
ring. Color bright brick-red, when living.

8 to 13 fathoms, south side of St. Ignace.

small specimen, probably the young of this species, taken in
15 fathoms, in Simmon's Harbor, was translucent, tinged
flesh color, with a dark brown intestinal line posteriorly.

phelis lateralis Verrill (*Hirudo lateralis* Say). A small
men, about 1 inch in length, of an obscure liver-brown
was taken, in 6 to 8 fathoms, among the Slate Islands,
h probably belongs to this species.

thyobdella punctata Verrill, sp. nov. Body, in extension,
er, in the preserved specimen, about ·5 of an inch long,
greatest diameter, rounded, thickest posteriorly, tapering
iorly to the anterior sucker, which is broad and thin,
ircular, about three times as wide as the neck where it is
ed. Ocelli four, on the upper side of the anterior sucker,
wo larger, black ones, in front, and two minute ones wider
and farther back. Posterior sucker large, rounded or
Color translucent greenish, with minute black specks
ged in transverse bands.

ong the Slate Islands, 6 to 8 fathoms.

Procotyla fluviatilis Leidy. Numerous specimens, app of this species, were obtained in 8–13 fathoms on the side of St. Ignace. They were, when living, dirty white, m with brown.

In addition to the preceding species of worms, a few obtained which have not yet been fully determined.

CRUSTACEA.

Mysis relicta Lovén. The occurrence of this and the f ing species, identical with forms from Lake Michigan, an lakes of northern Europe, is mentioned in the last numb this Journal. It was brought up with sand and mud fro to 14 fathoms at the eastern end of St. Ignace, from 8 fathoms, with *Cladophora*, on the south side of the island, and from deep water in a large proportion of the from 73 to 148 fathoms.

Pontoporeia affinis Lindström. This species was foun every haul from the shallowest to the deepest.

Crangonyx gracilis Smith, sp. nov. Eyes slightly elong black, composed of few facets. Antennulæ slender, slightly than half as long as the body; secondary flagellum but l longer than the basal segment of the primary. Ante much shorter than the antennulae; the flagellum and pedu of about equal length, the peduncle being a little longer t the peduncle of the antennulæ. Gnathipoda sub-equal both sexes, the second pair being only slightly larger than first; propodus in the first pair quadrate, the palmary ma transverse, nearly straight, and armed with slender spines, which one or two at the prominent posterior angle are m larger than the others; propodus in the second pair like th of the first, but a little more elongated and the palm margin slightly oblique. Third, fourth and fifth pairs pereiopoda equal in length and the margins of their b spinulose. Ultimate pleopoda reaching to the tips of t penultimate; the outer ramus nearly twice as long as t peduncle, and armed with slender spines; the inner ram very minute, shorter than the width of the outer. Tels scarcely as long as the bases of the ultimate pleopoda, slight broader than long, and the posterior margin with a triangu emargination, either side of which the extremity is trunc and armed with several spines.

The incubatory lamellæ of the female are very large, p jecting much beyond the coxæ of the anterior legs, as in *C.* *curvatus* Grube, which our species much resemble in the fo of the antennulæ, antennæ, gnathepoda, etc., while it diff much in the ultimate pleopoda and in the form of the telso Length, 5 to 7$^{\text{mm}}$.

Among *Cladophora*, in 8 to 13 fathoms, on the south side of
. Ignace.

Gammarus lacustris Smith, sp. nov. Eyes slightly elon-
ted, black. Antennulæ not quite half as long as the body,
d furnished with a few short hairs; first and second seg-
ents of the peduncle equal in length, third much shorter;
gellum twice as long as the peduncle. Antennæ a little
orter than the antennulæ; ultimate and penultimate seg-
nts of the peduncle equal in length, the basal segments
ort; flagellum considerably shorter than the peduncle.
athipoda about equal in size; propodus in the first pair
ngated and much narrowed toward the articulation of the
podus; palmary margin slightly concave, continuous with
posterior margin, and furnished, like it, with several stout
nes and numerous long hairs, dactylus slightly curved and
ly half as long as the propodus; propodus in the second
r a little broader, the lateral margins nearly parallel, the
mary margin somewhat oblique, slightly concave, and
nished with a thin raised margin, and several stout spines,
posterior margin without spines, but furnished with nume-
s fascicles of hairs. Pleon rounded above, the fourth and
h segments each with three fascicles of two or three small
nes. Third, fourth, and fifth pairs of pereiopoda sub-equal,
ir basa narrow and the margins furnished with few minute
nes. Rami of the posterior pair of pleopoda very slender,
edges furnished with long hairs and a few spines, inner
y a little shorter than the outer. Length, 15 to 20^{mm}.
olor in life uniform, obscure, dark brownish-green, with-
spots or markings of any kind.
ommon in company with the last species in 8 to 13
oms; also at Simmon's harbor, in 13 to 15 fathoms, and
ong the Slate Islands, in 4 to 6 and 12 to 14 fathoms.

sellus tenax Smith, sp. nov. Head broad, with a large
nded sinus in the margin on each side opposite the eye,
k of which the margin projects in a rounded lobe, so that
head is not narrower posteriorly than the anterior margin
he first segment of the pereion. Eyes small, prominent,
separated from the margin of the head by more than
r diameters. Antennulæ much shorter than the peduncles
the antennæ. Antennæ half as long as the body; the
ellum longer than the peduncle. Propodus in the first
of gnathipoda narrow and elongated, but considerably
ter in the male than in the female; dactylus more than half
ong as the propodus and its palmary edge armed with acute
es, of which the distal ones are larger. The succeeding
s of legs all similar, the carpal and propodal segments sub-
al in length and armed with short spines along the posterior

edges; the dactyli short, armed with a few spines on the p terior margin, and bi-unguiculate at tip. Pleon narrowed p teriorly, and the extremity obtusely rounded. Posterior opoda slender, the outer ramus only half as long as the in Length, 8 to 13^{mm}.

Color above dark fuscous, spotted and mottled with y lowish.

Common with the last two species, among the *Cladoph* in 8 to 13 fathoms; also in 4 to 6 fathoms at the eastern end o St. Ignace, and in 6 to 8 fathoms among the Slate Islan

Numerous species of Entomostraca were collected at ma places, but they have not yet been examined sufficiently for a enumeration of the species.

In addition to the species of the groups already mention insect larvæ and pupæ were obtained at nearly every ha Several species of *Chironomus*, or of closely allied genera, we common, a slender translucent species being found down t 147 fathoms; an Ephemerid lava occurred at 32 fathoms i Neepigon Bay, and two species of *Phryganeidæ* larvæ we common among *Cladophora* in 8 to 13 fathoms on the sout side of St. Ignace.

ART. LVIII.—*On Kilauea and Mauna Loa*; by Rev. TITUS COA

(From a letter to J. D. Dana, dated Hilo, Aug. 30.)

DURING the present month I have, in connection with my pa toral labors, visited Kilauea and the whole coast of Puna. I ha not seen the volcano since July, 1869, more than a year after th great earthquake and eruption of April, 1868. At this visit, i 1869, I found the crater very quiet. The central and *convex* part had subsided some four hundred feet, forming a vast *concave*, and leaving a high, serrous, black ledge around the circumference of the crater. The south lake was not included in the central basin or depression; but it formed a much deeper pit within the southern rim of the black ledge. The whole crater of Kilauea was then quiescent, with light puffs of long, white steam rising here and there. There were no demonstrations, and so nearly cooled was the bottom of that great south lake—Halemaumau—that I went down into it some *twelve hundred feet below the upper rim of Kilauea*, and measured across the floor. I found the diameter five-sixths of a mile, the pit being more than a mile wide from the upper north to the upper south rim. There were several places, however, at that time, where the incandescent rocks were seen boiling fiercely, through fissures, in caverns fifty to one hundred feet below. Such was the state of the crater on my visit in July, 1869.

On my recent visit, two years later, I found great changes. The south lake had been filled with molten lavas, and successive verflowings had covered deeply all the southern end of the rater, and sent off their fiery streams two miles to the north, overing the great central depression to the depth of fifty feet.

Mr. L. Kaina, an observant and intelligent Hawaiian, who eeps a respectable hotel at the volcano, told me that, from April o October, 1870 (while I was in the United States), repeated and rand overflowings occurred from Halemaumau, the fiery waves urging and dashing down the northern declivities, filling the hole crater with intense heat and stifling gases; it threw up a heet of lurid light toward the zenith, producing the appearance f a firmament in conflagration, and reminding one of the bold igures of Peter in speaking of "the heavens being on fire . . . and he elements melting with fervent heat."

My informant told me that he, several times, witnessed what I ave more than once seen, viz: the fiery lake rising slowly to the im, boiling and spilling over, and, by hardening in successive trata, raising a circular dam or barrier around the whole circumerence of the lake, some fifteen to twenty-five feet high. Within his circular dike or raised rim the molten sea boils and rages until he heat, the action, and the lateral pressure burst the conical shell, when the seething flood rushes out with awful power, and overs a vast area with its burning waves. Such a scene I witnessed shortly after I lost your pyrometer, which had been thrust into a fiery lake such as is here described. I judge that the overflowings from this south lake, during my absence, cover four square miles to a depth of fifty to three hundred feet—the deepest portion being an elevated region lying all around Halemaumau—and extending east, south, and west, to the outer walls of Kilauea, and flowing down a steep slope to the north, and sweeping over the great central concave.

I was in the crater on the 22d instant, and was at once surprised with the great changes manifest. I had no sooner descended from the northern terrace, or black rim, than I found myself on new ground. All old tracks and landmarks were obliterated. All was *recast.* About half a mile from the south lake I began to rise on an angle of some 25° until I was on a level with the rim of the cauldron. About three hundred yards from the pit the heat was so great, and the gases so pungent, that I could not proceed in a direct line to the margin. Being driven back I made a detour, and again attempted a direct approach. Failing in this, I retreated to a safer atmosphere, and then flanked the fiery pit at some distance, traveling southwestward for half a mile. Here I found the smoke and gases lighter, and again I advanced on the crater at right angles. With difficulty I succeeded in reaching the rim, and a puff of wind favoring by sweeping off the dense smoke of the pit in another direction, I caught a twenty-second glimpse of the awful abyss below. I judged the pit of Halemaumau to be seven hundred feet deep, one mile and a half long from east to west, and one mile from north to south. But it was full of dense columns of smoke and sulphurous gases which were rapidly rising from burning depths below, and being carried by the winds over all the regions I wished to traverse. Almost immediately after the opening, which revealed to me the profound depths of the fiery abyss, the whole pit was packed and darkened with still denser clouds of smoke, which the fitful wind began to drive upon me. I made a hasty retreat to the northwest, where I reached the original black-terrace, and, mounting an inactive cone some twenty-five feet high, rested in a current of cooler and purer air, and surveyed the marvelous scene I had just left. There is a great body of molten matter in this pit, recognized by its sullen mutterings, and splashings and surgings, and by the bloody glow thrown upon the uprising columns of smoke at night. But the heat and smoke are so great, that it is unsafe to approach the rim of the crater, and usually impossible to see the bottom even could you reach the margin of the pit.

The immense quantities of lava which came from this pit were not all thrown over the upper rim. After this rim had been raised with all the surrounding area, to a great height, the molten floods formed subterranean passages to the lower parts of Kilauea, where they burst out, and spread seas of liquid fire over the surface.

An active Crater on Mauna Loa.—While at Kilauea, the atmosphere being clear at night, I had a view of an active volcano on Mauna Loa some 13,000 feet high, and about four miles south by west of Mokuaweoweo, the summit crater. This volcano has been burning for weeks, though not often seen at Hilo on account of clouds. Its bearing is about southwest from Hilo, and, as I judge, about north from Kahuku in Kau. It is said that several Hawaiians of Kau have visited it. They say that it is a small lateral crater of Mokuaweoweo, about four miles distant. It has long been extinct, but it now boils in fiery swirls, much like Kilauea. Its action is unequal, sometimes throwing up brilliant jets, and clouds of smoke, and anon seething quietly in its deep caverns. It has not overflowed its rim, or rent its mural walls, or found any subterranean vent by which the molten lake passes off. From week to week and month to month it burns in solitude, and shines like a beacon light upon the dark mountain. Most of the time it is hidden from us by clouds; but when the old mountain—the mother of volcanoes—removes her misty veil, we can then see its distant light.

Some thirty-five or forty miles from Kilauea, and about 9,000 feet above it in altitude, how is it that we can see no sympathy that proves a subterranean connection?

We have occasional shocks of earthquake. From Kilauea I went down to the coast of Puna, and followed its shores to Hilo. The great subsidence of April, 1868, still remains. In most places the people have removed from the shore and built half a mile to two miles inland. In some places they now catch fish where once they cultivated vegetables and grazed their horses. The debris of that little cataclysm is still strewn along the shores of Puna and Kau.

SCIENTIFIC INTELLIGENCE.

I. CHEMISTRY AND PHYSICS.

1. *On the sensitiveness to light of the haloid salts of silver, and the connection between optical and chemical absorption of light.*—SCHULTZ-SELLACK has published with the above title a very interesting memoir, the principal results of which are, in the author's words, as follows:

(1.) In the case of a mixture of chlorine and hydrogen the curve of the chemical intensity of the spectrum which shows the relative chemical action which the different colors exert when completely absorbed, has a course different from that of the curve which directly expresses the observations of Bunsen and Roscoe, and probably more nearly resembles the curve of heat-intensity.

(2.) The sensitiveness to light, determined by photographic excitement, extends in the case of chloride of silver from the ultra-violet to $\frac{2}{3}$ HG; in the case of iodide of silver to $\frac{1}{8}$ GF; in the case of bromide of silver to $\frac{4}{5}$ GF, with iodo-bromide and iodo-chloride of silver to beyond E.

(3.) The dark coloration of haloid salts of silver exposed to the spectrum takes place in the case of chloride of silver within the extent of the photographic excitability; this is probably also the case with the other haloid salts.

(4.) In the case of the haloid salts of silver the absorption of light is always accompanied by chemical decomposition. These salts exert a perceptible absorption upon the spectrum only within the above mentioned limits of photographic excitability.

(5.) Only a small fraction of the absorbed light is converted into chemism. This fraction is different for different colors, but is never zero.

(6.) A thin film of iodide of silver absorbs the light which is more refrangible than G very strongly, the light between G and $\frac{1}{8}$ GF but feebly; this last is, however, photographically active. In photographing upon iodide of silver, the interposition of a thin film of the iodide acts like illumination with light approximately homogeneous from G to $\frac{1}{8}$ GF.

(7.) At a higher temperature the coloration of the haloid salts of silver becomes deep brown. The sensitiveness to light then probably extends to the red of the spectrum.

(8.) The application of the term *chemical rays* to the more strongly refrangible rays of the spectrum has no other signification than that known substances sensitive to light specially absorb precisely these rays.—*Pogg. Ann.*, cxliii, p. 161. W. G.

2. *On the proteine series.*—HLASIWETZ and HABERMANN have taken up the study of this somewhat neglected subject, and have arrived at results of much interest. The authors in the first place pass in review the results obtained many years since by the study of the products of the action of various reagents upon members of

the proteine group. These they compare with the products i the action of the same reagents upon the so-called carbon-hydra gum, starch, &c., pointing out the close relationship between th two classes of derivatives. The substances selected for exami tion were caseine, albumen and fibrine, vegetable albumen and le gumine. These substances were treated with bromine and wa as long as the bromine appeared to exert an action, and the p ducts of the action of bromine separated by processes for whi we must refer to the original paper. The results finally reach showed that under the circumstances the products of the deco position were—

Bromacetic acid,
Bromoform,
Carbonic acid,

Asparagic acid,
Malamic acid (?)
Oxalic acid,

Leucine,
Leucimid,
Capronic acid,

Tribromamido-benzoic acid.
Bromanil,

together with some ammonia and humus-like substances. Tyrosin was not found in any case; but the authors suggest that it was converted by the action of bromine into bromanil. The products were qualitatively the same for all the substances examined, but quantitatively different, so that the authors infer that the members of the group do not contain a common base like the proteine of Mulder. The action of bromine upon the proteine bodies, like that of other agents of decomposition, yields two classes of products—those which belong to the fatty and those which belong to the aromatic group. Neither of these groups contains more than six atoms of carbon in the principal chain, so that they may be considered as derived respectively from the hydrocarbons, $\text{Є}_6\text{H}_{14}$ and $\text{Є}_6\text{H}_6$. Only the highest terms are characteristic of the proteine bodies, namely—leucine, asparagic acid, glutamic acid and tyrosin. All the others are merely derivatives of them.—*Ann. der Chemie und Pharmacie*, clix, p. 304. W. G.

3. *On the products of the reduction of silicic ether and some of its derivatives.*—LADENBURG has studied the action of zinc-ethyl and sodium upon silicic ether. The first product of the reduction is the silico-propionic ether of Friedel and Ladenburg, $\text{Si}\text{Є}_2\text{H}_5(\Theta\text{Є}_2\text{H}_5)_3$. When this is repeatedly treated with zinc-ethyl and sodium, a second product is obtained which has the formula

$$\text{Si}(\text{Є}_2\text{H}_5)_2(\Theta\text{Є}_2\text{H}_5)_2.$$

The density of this liquid is 0·8752 at 0° C., and its boiling point 155°·5. The author terms it silicium diethyl-keton-ether. It is unchanged in the air, insoluble in water, soluble in alcohol and ether. By long boiling with caustic alkalies it is decomposed, and silico-propionic acid may be obtained from the solution. By treating with chloracetyl or chlorbenzoyl the ethyl groups are exchanged for chlorine, while acetic or benzoic ether is formed. Thus in the latter case we have—

$$\text{Si}(\text{Є}_2\text{H}_5)_2(\Theta\text{Є}_2\text{H}_5)_2+2\text{Є}_7\text{H}_5\Theta\text{Cl}=\text{Si}(\text{Є}_2\text{H}_5)_2\text{Cl}_2+ \\ 2(\text{Є}_7\text{H}_5\Theta\,.\,\Theta\text{Є}_2\text{H}_5).$$

ith one molecule of chloracetyl or chlorbenzoyl, the reaction is
ifferent; thus we have—

$$\mathrm{Si(\text{Є}_2H_5)_2(\Theta\text{Є}_2H_5)_2+\text{Є}_2H_3\Theta Cl=Si(\text{Є}_2H_5)_2Cl(\Theta\text{Є}_2H_5)}.$$

ilicium-diethyl-chlorethin, $\mathrm{Si(\text{Є}_2H_5)_2Cl(\Theta\text{Є}_2H_5)}$, boils at 148°
. ; silicium-diethyl chloride, $\mathrm{Si(\text{Є}_2H_5)_2Cl_2}$, at 129° C. Both
re liquids which fume in the air, and burn with a green bor-
ered flame, leaving silica. By the action of water upon the
iethyl chloride the author obtained a viscid syrup, the analyses
f which agreed tolerably with the formula, $\mathrm{Si(\text{Є}_2H_5)_2\Theta}$. The
uthor considers this substance identical with that obtained by
riedel and Crafts by the action of fuming nitric acid upon
ilicium-ethyl, and for which they proposed the same formula. By
he further action of sodium and zinc-ethyl upon silicium-diethyl
eton ether the author obtained an ether having the formula,
i$\mathrm{(\text{Є}_2H_5)_3(\Theta\text{Є}_2H_5)}$, which he terms silico-heptyl ether, boiling
t 153° C. Iodhydric acid reacts with this body according to the
quation:

$$\mathrm{2Si(\text{Є}_2H_5)_3(\Theta\text{Є}_2H_5)+2IH=(Si(\text{Є}_2H_5)_3)_2\Theta+2\text{Є}_2H_5I+\Theta H_2}.$$

Silicium triethyl oxide, $\mathrm{(Si(\text{Є}_2H_5)_3)_2\Theta}$, was first obtained by Friedel and Crafts. The new reaction furnishes a method of obtaining it more easily. In conclusion, the author points out a certain regularity in the physical properties of the best known members of the silicium-ethyl series. We have—

		Boiling point.	Density at 0°.
Silicic ether,	$\mathrm{Si(\text{Є}_2H_5)_4\Theta_4}$	166°·5	0·9676
Silico-prop. ether,	$\mathrm{Si(\text{Є}_2H_5)_4\Theta_3}$	158°·5	0.9207
Silico-diethyl-keton,	$\mathrm{Si(\text{Є}_2H_5)_4\Theta_2}$	155°·5	0·8752
Silico-heptyl ether,	$\mathrm{Si(\text{Є}_2H_5)_4\Theta}$	153·	0·8414
Silicium-ethyl,	$\mathrm{Si(\text{Є}_2H_5)_4}$	152°·5	0·7657

—*Berichte der Deutschen Chem. Gesellschaft, Jahrgang* iv, 726.
W. G.

II. GEOLOGY AND NATURAL HISTORY.

1. *Triassic Sandstone of the Palisade Range.*—The Triassic (or Triassico-Jurassic) rock, in New Jersey, as well as Connecticut, is generally a distinct granitic sandstone, that is, it is largely made up of pulverized granite or gneiss. This rock in the Palisade range, New Jersey, is very fine-grained, and has been called *felsite* by Prof. Wurtz, and also by Dr. P. Schweitzer, in a paper on its composition in the American Chemist, July, 1871, p. 23. Five specimens were analyzed, and all were *granular*, and feldspar could be readily distinguished under the microscope. Mr. Schweitzer found the first four to contain ingredients corresponding to 30 to 60 per cent. of albite, showing that the granitic rock out of which these New Jersey fine-grained sandstones were made was albitic. The rock from the Newark quarries consists, according to him, of albite 50·46 per cent, quartz 45·49, soluble silica

0·30, water 1·14, bases dissolved out by hydrochloric acid 2·1 100·30. It would be of geological interest to find the localit the albitic granitoid rocks that afforded the material for th sandstones (as we should call them, the term *felsite* being not for a rock of a peculiar constitution, but rather for one of f like or impalpable texture). The Triassic sandstones of the vicin of New Haven, Ct., contain orthoclase instead of albite, and t material is evidently from the rather coarse granites that lie ju west of the sandstone. D.

2. *Martius, Flora Brasiliensis.*—Fascicles 51, 52, 53 and 5 have all appeared during this current year; the first bears th date of February, the last of July, 1871. The enlightened Emperor of Brazil, while in Germany this year (where he visited th grave of von Martius, and plucked and preserved some flowers a a *souvenir*) had the satisfaction of observing the rapid progress o this great national work, under Dr. Eichler's efficient directio Dr. Eichler has this year been called to fill the chair of Botany a Gratz, with which is combined the directorship of the Botanic Garde But he is able to carry on the Flora of Brazil, which will still b printed at Munich. With the fascicles now published, title-page are issued for the volumes or parts of volumes (when the size o the volume calls for a division) already completed. It appear that eight volumes, or rather six half-volumes and two full volume are now ready for the binder.

Fascicle 51, by Doell of Baden, commences the *Gramineæ*, bu includes only the small tribes of *Oryzeæ* and *Phalarideæ*, th later in the Kunthian rather than the Brownian sense. The *squamulæ* are maintained to be some of them perigonial, but others o stipular nature, i. e., stipules of paleæ. *Oryza* is made to include *Leersia* as a section. *Oryza sativa* and *O. monandra*, *Coix lachryma*, and *Zea Mays* are figured, as also a few rarer grasses.

Fasc. 52, besides Meissner's supplement to *Convolvulaceæ* (Geography and uses) contains the *Cuscutaceæ* by Dr. Progel and *Hydroleaceæ* and *Pedalineæ* by A. W. Bennett of London. Dr. Progel claims for these plants the rank of an order, on the ground of the structure of the embryo, the amount of albumen, and the simply imbricative æstivation of the corolla. Yet in the diagnostic character we read; "*corolla* .... *lobis* .... *per æstivationem contortis.*" With good judgment, he refers all to the one genus *Cuscuta*, and gives a conspectus of all the tropical and subtropical American species, after Engelmann. Eighteen Brazilian species are described, one figured at large, and the flowers, seeds, &c., of all of them after the manner of Engelmann's original monograph, which led the way to the present understanding of the genus, and whose more recent and elaborate "systematic arrangement" is almost implicitly followed.

The *Hydroleaceæ* are equally maintained by Mr. Bennett as an independent order, a matter which may almost equally well be decided either way; but we have before alluded to a connecting link between this group and the *Hydrophyleaceæ* which our author erlooks. Five species of *Hydrolea* and one of *Wigandia* are all at are claimed for the Brazilian flora. The *Pedalineæ* count wo genera of a single species each and one of three species.

The 53d fasciculus contains the *Irideæ*, elaborated by Dr. Klatt Hamburg, and illustrated by 8 plates. It is stated that the nown species of the order amount to 470, of which 251 are frican, 109 American, 50 Asiatic, 42 European, and 13 Aus- alian. The Brazilian flora counts 57; but there is no *Iris* nong them, nothing nearer than a solitary *Cipura*. Nuttall's nus *Nemastylis* has a south Brazilian representative. *Tigridia avonia* would appear to inhabit Brazil as well as Mexico, and America is the home of *Sisgrinchium*, of which 21 species are razilian.

Fasc. 54 comprises the *Escallonieæ* and *Cunoniaceæ*, by Dr. ngler of Breslau, and the *Connaraceæ* and *Ampelideæ* by Mr. aker of Kew. *Escallonia* counts up to 43 species in Brazil, and *Veinmannia* almost as many. The 35 Brazilian species of *Con- raceæ* are divided among four genera; and there are good gures, with full details, filling seven plates. Of *Ampelideæ* ere are 35 species of *Vitis* (taken in the largest sense); and ve plates are given. The remaining orders of *Polypetalæ* will on be forthcoming, and then the *Euphorbiaceæ*. A. G.

3. *Baillon's Histoire des Plants*, in a series of monographs, is aking progress, notwithstanding all untoward events. We have efore us the monograph on *Menispermaceæ* and *Berberidaceæ*, ustrated by 73 admirable wood-engravings; and that on *Nym- æaceæ*, with 34 figures, both issued in 1871. The illustrations the *Cocculus* series are taken from *Anamirta Cocculus* (the ficinal Cocculus Indicus), our own *Cocculus Carolinus*, and the *enispermum Dahuricum*, which is very like our own species. he *Cissampelos* series has capital illustrations of the officinal *issampelos Pareira*. The *Chasmanthera* series, to which our *alycocarpum* belongs, is illustrated by *Chasmanthera Columba*, hich furnishes the Columbo of Madagascar.

Baillon follows Bentham and Hooker in referring the *Lardiza- leæ*, as a tribe, to the *Berberidaceæ*. But his great point is that finds in *Erythrospermum* of Lamarck, hitherto placed in the *ixaceæ*, another syncarpous Berberideous genus, nearly related the Chilian *Berberidopsis* of Hooker, and with it constituting new tribe. The name *Bongardia* he replaces by *Chrysogonum* Rauwolf and Bauhin (which would thus throw out Linnæus's wn genus *Chrysogonum*); this going back beyond Tournefort ould work endless trouble, if accepted; and by the same rule *Leon- ce* also should have given place to *Leontopetalum*. *Caulophyl- m* is naturally considered as a section of *Leontice*, and all the enera separated from *Epimedium* are suppressed. Baillon has ot mentioned the fact announced in this Journal, that *Podophyl- m* occasionally exhibits more than one carpel, and he signifies a oubt whether the pulpy investment of the seeds is an arillus. his, however, the fresh fruit makes clear.

The *Nymphœaceæ* are taken in the most enlarged sense, and are made to include the *Sarraceniaceæ*, which is surely wi beyond the mark. *Nelumbo*, *Cabomba*, *Nuphar*, *Nymphæa*, *Euryale* are well illustrated; the latter genus is made to inc *Victoria;* the quasi-monocotyledonous stems are described, &c. i the first instance the ovules of the *Cabombeæ* are said to be inser in the internal angle of the ovaries (ventral suture); elsewh they are more correctly said to be borne on the parieties of t cell; but it is nowhere mentioned that they are more commo on or near the dorsal suture, and very rarely indeed upon th ventral, as Salisbury and then Brown long ago pointed out.

We should add that this important work, as fast as it appea is translated into English and published in London, under the nam of *A Natural History of Plants.* Reeve and Co. are the publishers. They issue it in monthly numbers, and the first volume is already issued, at 25 shillings; it has 503 wood-engravings.

A. G.

4. *Baptisia perfoliata; the arrangement and morphology of th Leaves.*—In a paper sent by Mr. Ravenel to Prof. Gray, and read by him at the last meeting of the American Association for the Advancement of Science, the character of the torsion of the stem by which the foliage on summer shoots becomes unilateral, is explained. It had been hastily supposed by the present writer that the leaves were five-ranked, and became one-ranked by a continuous torsion of the stem. Mr. Ravenel points out that the phyllotaxis of the plant in question is really of the two-ranked order, which inspection of the growing shoots makes abundantly clear, and that they become one-ranked by the alternate twisting of the successive internodes right and left, i. e., one twists to the right, the next as much to the left, the next in the opposite direction, and so on, thus bringing the leaves into a vertical position all on one side of the horizontal branch. It occurred to Mr. Ravenel that this vertical position of the leaves was correlated with the remarkable alternate torsion of the axis, namely, that the leaves on the reclining branches were adjusting themselves so as to present their two faces as equally as possible to the light, as is done by those of the Compass plant in a different way; and that it was therefore probable that the stomata would be found to be as numerous on the upper face of the leaf as on the lower. A microscopical examination proved the correctness of Mr. Ravenel's conjecture; the stomata are about equally numerous on the two faces. Whether the leaves take a vertical position because the stomata occupy both surfaces, or whether the stomata are so distributed because the leaves stand edgewise to the zenith, is a question. The fact is that the two are thus correlated, and such correlation is ordinarily essential to the well-being of the plant. It may be remarked, however, that the stomata do not manifestly appear until the leaf is pretty well developed. Also that this distribution of the stomata is peculiar to the species in question. At least the leaves of *B. australis* and *B. leucantha*, which retain

eir horizontal position, are provided with stomata only on their ver face. The question next arises whether *B. perfoliata* really fers in its normal phyllotaxis from its congener. We find that does not, that in *B. australis*, *leucantha* and *alba*, and in *B. foliata* likewise (these being all the species at present cultivated the Cambridge Botanic Garden), the arrangement of the leaves the base of the main stem is of the tristichous order, but that er the first or second cycle, especially on the branches, this anges to the distichous order. The difference between *B. periata* and its congeners, therefore, is not in the normal arrangent of the leaves, but in the fusion of the axis and the distribun of the stomata, adopting the foliage to its vertical position.

The form of the leaves in *Baptisia perfoliata* is remarkably uliar. Most of the species have trifoliate leaves and a pair stipules; this has to all appearance a simple and entire perate leaf and no stipules. It is, however, a natural supposition t the apparently simple leaf consists either of a pair of stipules, of such stipules and a leaflet, connate into a rounded disk. is supposition Mr. Ravenel has just now had the good fortune verify, by finding some abnormal shorts of *B. perfoliata*, one which is in our possession. Most of its leaves are cordate-clasp- rather than perfoliate, and with or without a retuse or emarate apex; some almost two-parted so as to represent pretty iously a pair of stipules; and one of like conformation but h an obvious terminal leaflet in the sinus! Mr. Ravenel reks that this is a manifest step toward his own *B. stipulacea*. ; it hardly invalidates that species, although the inflorescence legume of the two are quite alike. A. G.

Drosera (*Sundew*) *as a Fly-Catcher*.—A valued corresponent and accurate observer, Mrs. Treat of Vineland, New Jersey, tes:

For several summers in succession I have taken *Drosera ndifolia*, *D. longifolia* and *D. filifolia* from their moist beds, placed them in sand and water in such a way that they made t charming window-plants. What I take for *D. longifolia* has ulate-oblong reddish leaves, and long, erect, reddish petioles ered with glands, like those of the leaf. This species I find a h more effective fly-trap than *D. rotundifolia*. On some of plants in my window this summer almost every leaf held a mon house-fly prisoner until it died, and it did not take the leaf y long to fold completely round its victim. My husband was ibly shocked, and thought it the most cruel thing he ever saw ature; but with my prepossessions and habits, both as an entoogist and a house-keeper, I was contentedly interested to see work go on."

we rightly remember, in *D. rotundifolia* it is only the glanded bristles that bend inward and hold the insect fast, while probably suck the juice out of him. This folding of the le of the leaf itself around the fly is a new fact to us, and is specially interesting, being a step toward *Dionæa*, that we would call particular attention to it, in the hope of further ob- vations and independent confirmation. We are told that the li incurves from apex to base, in the manner of its vernation. W was long ago known of the action of *Drosera rotundifolia* in catching, had almost completely died out of the books and out the memory of the present generation until very lately, and most remarkable things relating to it and to *Dionæa* are not in print. A. G.

6. *Borodin: Changes in position of grains of Chloroph under Sunlight.*—The singular and prompt change in the posi of the chlorophyll grains, discovered by Famintzin and verif by Borodin in Mosses, has been found by the latter to occur in higher Cryptogamia as well, and now also in Phanerogam plants, both aquatic and terrestrial. The paper in Bull. Acad. S Petersb. vol. 13, 1869, is reproduced in the Ann. Sci. Nat., ser. t. 12. *Lemna*, *Ceratophyllum* and *Callitriche* are among th aquatic plants in which the phenomenon has been observed, a *Stellaria media* among terrestrial. *Lemna trisulca* is one of th best plants for these observations. Under diffuse day-light th grains of chlorophyll are distributed over the cell-walls paral to the surface of the leaf or frond. Under the direct light of th sun they are rapidly (within 15 minutes or less) transported to th lateral walls. There they are at first uniformly distributed. Bu upon longer insolation, say for three-quarters of an hour, they became grouped in clusters. In darkness the chlorophyll is like wise upon the lateral walls. Thus absence of light produce essentially the same effect as direct sunshine, but less strikingly Whether these changes are passive and caused by movements the colorless protoplasm, as Sachs supposes, or active, is not mad out. But the movements, according to Borodin, are in respon only to the more refrangible rays. A. G.

7. *Dehérain: Evaporation of Water and decomposition of Carbonic acid by foliage.*—Some notice of Dehérain's papers read before the Academy of Science, Paris, in August and Octo ber, 1869, have already been referred to in this Journal. A full abstract published last summer in the Am. Sci. Nat. (ser. 5, tome 12) has come to hand. One of the first and least expected results which came to light early in the investigation, and simplified the experiments considerably, was:—

(1.) That the transpiration of water continued indefinitely, and quite constantly, in a saturated atmosphere.

(2.) This evaporation, copious in light and almost null in darkness, is determined by the light, and not by the heat of the sun.

(3.) It is much greater from young leaves than from older ones.

(4.) And is mainly caused by the luminous rays (yellow and red).

(5.) The difference in this respect is manifest even when the less refrangible and more refrangible rays are brought to an equal luminous intensity.

(6.) The evaporation of water is much more copious from the upper than from the lower face of the leaf. This result, in view

the structure of the leaf, and the situation of the stomata, is
st unexpected.

7.) Since the decomposition of carbonic acid also takes effect
ler the yellow and red rays mainly, and in the upper rather
n the lower face of the leaf, the relation between these two
ital functions of foliage appears to be intimate and is certainly
eworthy. A. G.

. *Herbarium.*—The Herbarium of a veteran European Bo-
ist, one of much importance, is offered for sale, the proprietor
hing to see to its satisfactory disposition during his life-time, if
sible. Particulars may be obtained from the writer of this
ice upon enquiry addressed to the editors of this Journal.

A. G.

III. ASTRONOMY.

. *Note on the Spectrum of the Aurora;* by GEO. F. BARKER.
In the evening of November 9th, there appeared one of the
st magnificent crimson auroras ever seen at this place. When
; observed, at about a quarter before six, P. M., it consisted of a
liant streamer shooting up from the northwestern horizon;
was continued in a brilliant red, but rather nebulous mass of
it, passing upward and to the north. Its highest points were
n 30° to 40° in altitude. A white aurora, consisting of bright
amers, appeared simultaneously, and extended round to the
theast.*

'he crimson aurora was examined with the spectroscope at six
ock. The instrument used was a single glass-prism spectro-
pe, made by Duboscq of Paris. On directing the slit toward
brilliant streamer above mentioned, a bright spectrum was
erved, consisting of five well-marked lines. A millimeter scale
ched to the instrument was then illuminated with a gas-flame,
auroral lines being readily measured, even when the numbers
he scale were bright enough to be read distinctly. The sodium
was used to adjust the scale, being equally divided by the
sion 100; the width of the slit was about one millimeter. As
s arranged, the five auroral lines, beginning at the red end,
the following positions: Scale-Nos. 90, 110·5, 130, 138, 149.
brightness of the lines was, following the above order, 3, 1, 5,
, the second line from the red end of the spectrum being the
ghtest. The line marked 90 and the one marked 110·5 were
rp and well-defined; the others were all nebulous on the edges.
ore the measurements were completely verified by a second
parison, the crimson aurora entirely vanished, having endured
than a half hour. In the white aurora which remained, the
troscope showed four of the five lines given; the crimson line

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Professor Newton informs me that he observed an equally brilliant red patch
uroral light in the northeast, five or ten minutes earlier. Since the lower end
e red streamers was much lower than that of the white, it would seem as if
'ed were seen through the white, the red being most remote.

alone was absent. The measurements are exact to half a divi of the scale.

To determine the approximate wave-lengths of these lines parison was made both with certain elemental lines and with lines of the solar spectrum. On the scale of this instrument, elemental lines employed read as follows:—

K*α* 63, Li*α* 79, Sr*β* 80, H(*c*) 82, Ca*α* 91, Sr*α* 96, Ca*β* 113, H(*f*) 14
Sr*δ* 163, Cs*β* 165, Cs*α* 167, Rb*α* & *β* 200, K*β* 218.

The Fraunhofer lines measured as follows:—

a 70·5, B 76, C 82, D 100, E 124·5, *b* 130, F 146·5, G 18

Direct interpolation was used in comparing the wave-length the auroral lines with those given above, the wave-lengths of Fraunhofer and elemental lines being taken from Gibbs's ta (this Journal, II, xliii, 1; xlvii, 194). This method was belie capable of giving results as close as the instrumental meas ments. In this way the wave-lengths of the five auroral li were obtained as given in the following table:—

Line.	Scale number.	Wave-length.	Auroral lines.	Other measurem
B	76	687		
C	82	656		
(1)	90	623	623	627 Zöllner.
D	100	589		
(2)	110·5	562	562	557 Angström.
E	124·5	527		
(3)	130	517	517	520 Winlock.
b	130	517		
(4)	138	502	502	
F	146·5	486		
(5)	149	482	482	485 Alvan Clark,
G	189	431		

In this table, column 1 gives the auroral and the Fraunhofer li column 2, the number of these as measured upon the scale of t spectroscope used; column 3, the wave-lengths of these lines tained as above stated; column 4, the wave-lengths of the sam lines, given by themselves; and column 5, the wave-lengths what I assume to be the same lines, with their wave-lengths measured by the observers mentioned.

The point of particular interest in this observation is the that the line (4) of wave-length 502 is not laid down in any auth ity accessible to me as having been observed in the auroral sp trum. Indeed, no previous observer, so far as I know, has any auroral line between the Fraunhofer lines *b* and F. Profes C. A. Young (this Journal, III, ii, 332, Nov., 1871) gives two li —Nos. 56 and 57, or 1866·8 and 1870·3 of Kirchhoff—observed him in the sun's chromosphere and also by Rayet in the eclips 1868, one of which may coincide with this fourth auroral line.

New Haven, Nov. 13, 1871.

Note.—Since the above was in type, the *Astronomische Nach*- *hten* for October 24th, No. 1864, has been received. It con- ns a notice of auroral spectra as observed at the Bothkamp servatory by H. Vogel, which is dated August, 1871. In ordi- y auroras 6 lines were seen, in the red streamers 7. The fol- ing are the wave-lengths given:—

	629·7	Very bright line.
	556·9	Brightest line of the spectrum. Markedly weaker when the red line is also present.
	538·2	Very faint line. (Doubtful.)
	523·3	Pretty bright line.
	518·9	Very bright when the red line is present. At other times, as bright as the last.
	500·3	Pretty bright line.
om	469·4	Broad band, brighter in the center. Very weak in the red streamers.
o	462·9	

e line of wave-length 500·3 is apparently the same observed by , and given as 502.

ogel thinks he has obtained evidence in support of the assump- n that the auroral spectrum is an air spectrum, modified by ditions of pressure and temperature.

he whole number of lines which have been seen and measured he spectrum of the aurora by different observers appears to be as follows:—

o.	Description.	Wave-length.	Observer.
		640 630	H. R. Procter.
1.	Bright red line	629·7	Vogel.
		627·9	Zöllner.
		623	Barker.
2.	Brightest line in the spectrum	562	Barker.
		557	Winlock.
		556·9	Vogel.
		556·7	Angström.
3.	Band	544	Winlock.
4.	Very faint line	538·2	Vogel.
5.	Band (coronal line?)	532	Alvan Clark, Jr.
		531	Winlock.
6.	Pretty bright line	523·3	Vogel.
		520	Winlock.
7.	Bright line (*b*?)	518·9	Vogel.
		517	Barker.
8.	Pretty bright line	502	Barker.
		500·3	Vogel.
9.	Band (F?)	485	Alvan Clark, Jr.
		482	Barker.
0.	Band	462·9 to 469·4	Vogel.
		464	Winlock.
1.	Band (G?)	434	Alvan Clark, Jr.

Many other observations of auroral spectra have been made, but in most cases the lines were not measured even approximately.

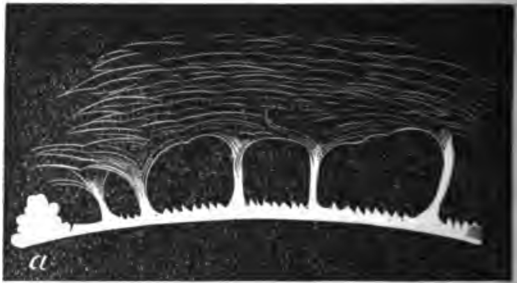
G. F. B.

2. *An Explosion on the Sun;* by C. A. YOUNG. (Boston Journal of Chemistry).—On the 7th of September, between half past twelve and two P. M., there occurred an outburst of solar energy remarkable for its suddenness and violence. Just at noon the writer had been examining with the telespectroscope* an enormous protuberance of hydrogen cloud on the eastern limb of the sun.

It had remained with very little change since the preceding noon—a long, low, quiet-looking cloud, not very dense or brilliant, nor in any way remarkable except for its size. It was made up mostly of filaments nearly horizontal, and floated above the chromosphere† with its lower surface at a height of some 15,000 miles, but was connected to it, as is usually the case, by three or four vertical columns brighter and more active than the rest. Lockyer compares such masses to a banyan grove. In length it measured 3′ 45″, and in elevation about 2′ to its upper surface—that is, since at the sun's distance 1″ equals 450 miles nearly, it was about 100,000 miles long by 54,000 high.

At 12^h 30^m, when I was called away for a few minutes, there was no indication of what was about to happen, except that one of the connecting stems at the southern extremity of the cloud had grown considerably brighter, and was curiously bent to one side; and near the base of another at the northern end a little brilliant lump had developed itself, shaped much like a summer thunder-head. Figure 1 represents the prominence at this time, *a* being the little "thunder-head."‡

1.



What was my surprise, then, on returning in less than half an hour (at 12^h 55^m), to find that in the meantime the whole thing had been literally blown to shreds by some inconceivable up-rush from meath. In place of the quiet cloud I had left, the air, if I ay use the expression, was filled with flying débris—a mass of tached vertical fusiform filaments, each from 10″ to 30″ long by or 3″ wide, brighter and closer together where the pillars had rmerly stood, and rapidly ascending.

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* This is the name given by Schellen to the combination of astronomical telescope and spectroscope.

† The *chromosphere* (called also *sierra* by Proctor and others) is the layer of hydrogen and other gases which surrounds the sun to a depth of about 7,000 miles. Of this the prominences are mere extensions.

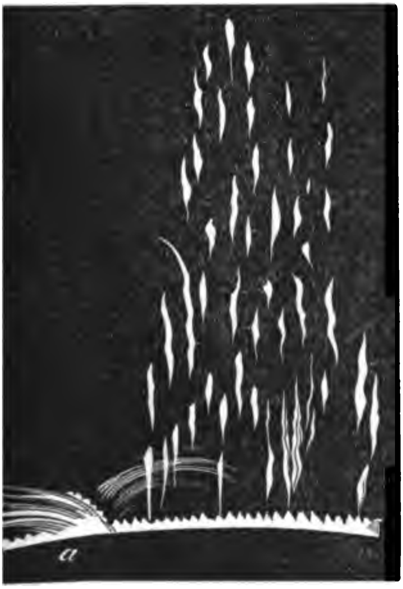
‡ The sketches do not pretend to accuracy of detail, except the 4th; the three *rolls* in that are nearly exact.

When I first looked some of them had already reached a height nearly 4′ (100,000 miles), and while I watched them they rose th a motion almost perceptible to the eye, until in ten minutes ^{h} 05^m) the uppermost were more than 200,000 miles above the lar surface. This was ascertained by careful measurement; the an of three closely accordant determinations gave 7′ 49″ as the treme altitude attained, and I am particular in the statement cause, so far as I know, chromospheric matter (*red-hydrogen* in is case) has never before been observed at an altitude exceeding

The velocity of ascent also, 166 miles per second, is considerly greater than anything hitherto recorded. A general idea of appearance, when the filaments attained their greatest elevation, y be obtained from figure 2.

As the filaments rose they gradually faded away like a dissolving ud, and at 1^h 15^m only a few filmy wisps, with some brighter streamers low down near the chromosphere, remained to mark the place.

2.

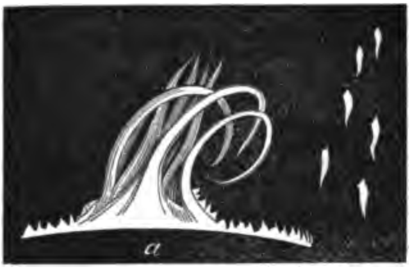


But in the meanwhile the little "thunder-head," before alluded to, had grown and developed wonderfully into a mass of rolling and ever-changing flame, to speak according to appearances. First it was crowded down, as it were, along the solar surface; later it rose almost pyramidally 50,000 miles in height; then its summit was drawn out into long filaments and threads which were most curiously rolled backward and downward, like the volutes of an Ionic capital; and finally it faded away, and by 2^h 30^m had vanished like the other. Figures 3 and 4 show it in its full development; the former hav- been sketched at 1^h 40^m, and the latter at 1^h 55^m.

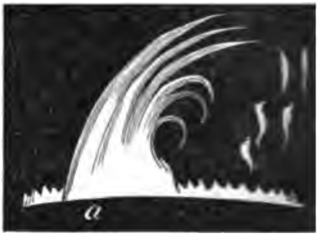
The whole phenomenon suggested most forcibly the idea of an *losion* under the great prominence, acting mainly upward, but in all directions outward, and then after an interval followed a corresponding in-rush: and it seems far from impossible

that the mysterious coronal streamers, if they turn out to be t
solar, as now seems likely, may find their origin and expla
in such events.

3.



4.



The same afternoon a portion of the chromosphere on the opp
site (western) limb of the sun was for several hours in a state
unusual brilliance and excitement, and showed in the spectru
more than 120 bright lines whose position was determined a
catalogued,—all that I had ever seen before, and some 15 or
besides.

Whether the fine aurora borealis which succeeded in the eve
ing was really the earth's response to this magnificent outburst
the sun is perhaps uncertain, but the coincidence is at least su
gestive, and may easily become something more if, as I somewh
confidently expect to learn, the Greenwich magnetic record ind
cates a disturbance precisely simultaneous with the solar explosio

Dartmouth College, September, 1871.

3. *November Meteors in* 1871.—On the night of Novembe
13th–14th, the writer, with Prof. Lyman and about two others
watched for meteors from 11^h 20^m onward, with the following re
sults:—

Between	11^h 20^m	and	11^h 30^m	we saw	9	meteors.	Sky $\frac{2}{5}$ obscured
"	30	"	45	"	8	"	Fewer clouds, [but hazy.
"	45	"	12 0	"	3	"	
"	12 0	"	15	"	8	"	
"	15	"	30	"	17	"	Nearly clear.
"	30	"	45	"	13	"	
"	45	"	1 0	"	15	"	
"	1 0	"	15	"	14	"	Sky $\frac{1}{5}$ overcast.
"	15	"	30	"	5	"	
"	30	"	45	"	6	"	Sky $\frac{9}{10}$ overcast.

Shortly after 1^h 45^m the clouds had entirely closed over, and did not break away afterward. A very few of the 98 meteors seen were of the November meteor system, not more, we judged, than $\frac{1}{10}$ of the number seen. We were therefore at the time of the watch not in the meteor stream. If the earth passed through it this year, it did so earlier than 11^h 20^m, or later than 1^h 20^m, of the night of the 13th–14th. H. A. N.

4. *Asteroid* (117).—This new planet was discovered by Borelly t Marseilles two days before it was seen by Luther. It has reeived the name *Lomia*.

5. *Tuttle's Comet*.—This comet, first discovered by Méchain in 790, and again by Tuttle in 1858, and which has a period of 13·6 years, was again seen at Marseilles October 15th, and at Karlsruhe October 15th.

IV. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Plattner's Manual of Qualitative and Quantitative Analysis with the Blowpipe*, from the last German edition, revised and enlarged by Professor THEODORE RICHTER, of the Royal Saxon Mining Academy. Translated by HENRY B. CORNWALL, A.M., E.M., Assistant in the Columbia College School of Mines, New York, assisted by JOHN H. CADWELL, A.M. With 87 wood-cuts and 1 lithographic plate. xv and 549 pp. 8vo. New York, 1872. (D. Van Nostrand, 23 Murray St.).—Plattner's celebrated work has long been recognized as the only complete book on blowpipe analysis. The fourth German edition, edited by Prof. Richter, fully sustains the reputation the earlier editions acquired during the lifetime of the author, and it is a source of great satisfaction to us to know that Prof. Richter has coöperated with the translator in issuing the American edition of the work, which is in fact a fifth edition of the original work, being far more complete than the last German edition.

The American editor, Mr. Cornwall, has done a very great service for all students of chemistry and mineralogy who use the English tongue, in thus adding to our scientific literature a work of such rare merit. He has showed excellent judgment in rendering the work into good English, in avoiding needless repetitions, in adding a large amount of valuable material, and in adopting a mineralogical nomenclature which is familiar to American scientific men.

2. *Geological exploration under* Dr. HAYDEN.—The geological expedition to the Rocky Mountain region under the charge of Dr. Hayden, after completing the survey of the Yellow Stone Valley, left Fort Ellis on the 5th of September, passing down Gallatin Valley to the Three Forks, and thence by the Jefferson to its very source, exploring many of its branches, and pursuing a direction nearly parallel to that which the party had traversed in the June previous.

The valleys of the Gallatin, Madison and Jefferson forks of the Missouri, with all the little branches, were found occupied by industrious farmers and miners—a contrast quite striking to the doctor, who, twelve years ago, in exploring that same region, met with not a single white inhabitant.

The Rocky Mountain Divide was crossed at the head of Horse

Plain Creek, from which the party passed over into Medi Lodge Creek, following this down into the Snake River Pla An interesting fact observed was the occurrence of two specie trout in great quantity in streams such as Medicine Lodge, Cam and other creeks, all sinking into the plains after a course of fro fifty to seventy-five miles. The trout appeared to be of the sa two species in all, although the waters had no apparent connectio —X., *in Harper's Weekly.*

3. *Madagascar.*—Few geographical researches of modern tim have been more interesting than those carried on in Madagasc by M. A. Grandidier, whether we consider our previous ignorance of the region in question or the number of striking and importan scientific novelties brought to light. We have already referred t the return of this gentleman from his third expedition, the fir having been commenced in 1865. On this occasion he attempted to reach the heart of the island, but in vain; and in the following year he explored the southern region, but did not reach the moun ains. In 1869–70, however, he traversed the entire breadth of th island three times, from west to east, through its whole extent making various lateral excursions to interesting points, and visiting the peak of the mountain Ankaararatre, the highest summit i Madagascar. According to the report just presented by M. Grandidier to the Academy of Sciences of Paris, Madagascar comprises two distinct regions—the northern, which is mountainous, and that to the south and east, which is flat. He ascertained that there are five chains of mountains, which have generally the same direction —namely, from northeast to southwest. These are separated by sandy and arid plains, intersected by shallow ravines. After crossing the fourth chain, a region is reached of which the general level is from 1000 to 1200 meters in height, extending to the Indian Ocean, a vast sea of mountains, with no level lands except a few small valleys used for the cultivation of rice.

The eastern coast is intersected at almost every step with rivers and torrents; and the northwestern provinces pour into the sea a large number of important rivers. On the southern and western regions, however, the case is quite different, there being distances of fifty leagues without the smallest brook. The reputation possessed by Madagascar for luxuriant vegetation and fertile soil according to M. Grandidier, is by no means merited, its provinces being neither rich nor productive. The secondary plains are sterile, and the population is confined to the immediate banks of the water-courses. The entire mass of the granitic mountains, situated to the west of the eastern slope, is naked and arid, and there is no vegetation excepting here and there little bunches, growing in the ravines. In the opposite direction, however, there is some degree of fertility; and there is a line of forests extending from north to south, which connect with those of the west, forming around the island a narrow girdle, including a dry and desert region in its center.

M. Grandidier made numerous astronomical, meteorological, and magnetical observations. He also studied closely the ethnology of the inhabitants, having taken a great many measurements upon the living body, and having collected notes of the habits, language, and traditions of the people. His natural history collections embrace over fifty new species of vertebrates, together with numerous nsects and plants. Large numbers of alcoholic specimens were also gathered, for the purpose of further investigation into the anatomy and structure of the entire animal.—X., *in Harper's Weekly.*

4. *Dr. A. Habel.*—After a seven years' tour of exploration in South America, Dr. A. Habel, a former resident of Hastings-on-the-Hudson, has returned to New York, where he is assiduously engaged in preparing the results of his labors for the press. Among the regions traversed by this gentleman may be mentioned the greater part of Central America, the Cordilleras of the Andes in Colombia, Ecuador, and Peru, and finally the Chincha Islands and the Galapagos. During this whole period Dr. Habel was diligently occupied in gathering information in regard to the natural and physical history of the countries mentioned, especially in the departments of ethnology, meteorology, and zoology. He has already made some communications on the subject of his travels to the Academy of Sciences at Paris, and other learned bodies, and we look forward to his detailed report with anticipations of much interest. The guano deposits of Chinchas were thoroughly explored by the doctor, who found them to be of a much more complicated structure than has hitherto been supposed.—X., *in Harper's Weekly.*

5. *On Sea Waves;* by W. J. MACQUORN RANKINE, C.E., LL.D., F.R.S. (Royal Institution of Great Britain, May 26, 1871.)—The speaker in the first place gave a summary, illustrated by diagrams and machines, of the existing knowledge of the mode of motion of water in waves, and of the geometrical and dynamical laws which govern the relations between the depth of disturbance of the water, the velocity of advance of waves, their periodic time, and their length. He referred to the experimental and theoretical researches of previous authors on the subject, such as Webers, Airy, Scott Russell, Caligny, etc.

He then explained the principle, of which Mr. Froude was the first to point out the importance, that the action of water agitated by waves upon a ship tends to make her perform the motions which would have been performed in her absence by the mass of water that she displaces. In still water, the forces of gravity and of buoyancy tend to keep the ship upright, and if she has been heeled over, to restore her to the upright position, and that tendency constituted the *statical stability* or *stiffness* of the ship. Among waves, the same forces, combined with the reactions due to the heaving motions of the water and of the ship, tend to place her in the position called *upright to the wave surface;* that is, with her originally vertical axis normal to the wave surface. If the ship yielded passively to that tendency, like a broad and shallow raft she would accompany the waves in their rolling; and thus, a ship having great *stiffness* may be very deficient in *steadiness*. Every ship has, like a pendulum, a natural period of rolling, depending on her stiffness, or tendency to right herself, and her moment of inertia, being a quantity depending on the distribution of her mass. Stiffness tends to shorten, and inertia to lengthen, the period. It was shown in 1862, by Mr. Froude, that the greatest unsteadiness and the greatest danger of being overturned takes place when the periodic times of rolling of the ship and of the waves are equal: for then each successive wave adds to the extent of roll; and if the coincidence of the periods were exact, the ship would inevitably be overturned in the end.

In the course of the present spring it has been pointed out that in well-designed ships a safeguard exists against the occurrence of such disasters. It is well known that no pendulum is absolutely isochronous; but great oscillations occupy a longer time than small oscillations. In like manner, no ship is absolutely isochronous in her natural rolling; but great angles of roll occupy longer periods than small.* Hence, supposing a ship to encounter waves of a period equal or nearly equal to her own natural period for small angles of roll, her angle of rolling is at first progressively increased: but at the same time her natural periodic time of rolling is increased, until it is no longer equal or nearly equal to the periodic time of the waves; and thus she in a manner *eludes* the danger arising from coincidence of periods. In order, however, that this safeguard may act efficiently, it is essential that the natural period of the ship for the smallest angles of roll should not be less than the period of the waves; otherwise the first effect of the progressive increase of angle will be, not to destroy, but to produce coincidence of period; and the result will be great unsteadiness of motion, and possibly great danger.

The speaker described the above principles as being the latest additions to our knowledge of the theory of the relations between ships and sea-waves; and he illustrated them by means of experiments on a machine so constructed as to imitate the dynamical condition of a ship rolling among waves.

6. *On a Meteor seen at Alexandria, Egypt;* by BEVERLY KENNON, Colonel Coast Defense, Egyptian Army. (From a letter dated Alexandria, Egypt, Sept. 9th, 1871, addressed to Rear Admiral Sands, U. S. N., and by him communicated for this Jour-

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* An exception to this rule exists in the case of that form of ship known as the "Symondite," in which the sides flare out at and near the water-line, so as to make the stiffness increase faster than the angle of heel. In such ships the period of rolling *shortens* when the angle increases; and thus the well-known unsteadiness of large vessels of that model is accounted for. In a small boat, whose natural periodic time for the smallest angle of roll is shorter than that of any of the waves which she encounters, the Symondite model does not promote unsteadiness; for the shortening of the natural period of rolling removes it farther from coincidence with the period of the waves.

nal.)—The meteor attracted my attention last night (Sept. 8th) and also that of my companions, and many other persons who were in the café on the sea-shore with me when it passed us in its light. It was very large and bright, and starting from the zenith moved nearly due north, and exploded or disappeared when about 20° above the horizon, and about S.E. from the North Star. It moved leisurely and disappeared apparently behind a cloud; when watching for its reappearance, we were astonished to find that the uminous streak which marked its passage appeared to remain tationary from the point at which the meteor disappeared. As it naintained its brilliancy for some seconds, I noted the time by watch; it was then 11ʰ 14ᵐ 30ˢ P. M. M. A. time. For one minute and ten seconds this brilliant streak, stretching toward the northern sky, and subtending an angle of about six degrees, remained erfectly straight and very bright; at the expiration of another ninute it had changed its shape into that of a curve, convex oward the earth; at the end of two minutes and thirty seconds t was obtuse-angled, and of moderate brilliancy; at the end of he third minute it was right-angled in shape, and of a distinctness sufficiently great to attract attention, disappearing entirely fter three minutes and twenty seconds from the time we first oticed it.

7. *Kansas Academy of Sciences.*—The Kansas Natural History ociety, of Leavenworth, Kansas, changed its name to that of the ansas Academy of Sciences, at its fourth annual meeting on the 5th and 26th of October. The officers of the Academy are Gen. ohn Fraser, President; B. F. Mudge and Robert J. Brown, Vice residents; John D. Parker, Secretary; F. H. Snow, Treasurer; B. F. Mudge and F. H. Snow, Curators. Several papers were read t the meeting on the Natural History and Geology of Kansas nd on other topics.

8. *The Fossil Plants of the Devonian and Upper Silurian of anada*, by J. W. Dawson, LL.D., F.R.S., F.G.S. Geological urvey of Canada, Alfred R. C. Selwyn, F.G.S., Director. 100 pp., ith 20 plates. Montreal, 1871. (Dawson Bros).—Dr. Dawson as here brought together the results of his long labors on the fossil Paleozoic botany of Canada, and made a volume of great value o Geology and to science in general. Its twenty plates are rowded with excellent figures. The closing chapter, forming a supplementary section" to the volume, is republished on page 10 of this number. The memoir is worthy to take its place along ide of the other Paleontological publications of the Canada Geogical Survey.

Bulletin of the Wisconsin Academy of Sciences, Arts and Letters, Nos. 4 and 5, r Feb. and July. pp. 48 to 81. Madison, Wis.

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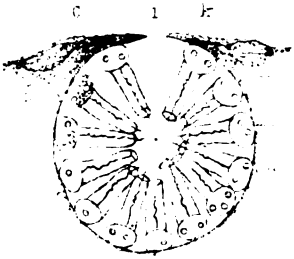
PALAEOZOIC



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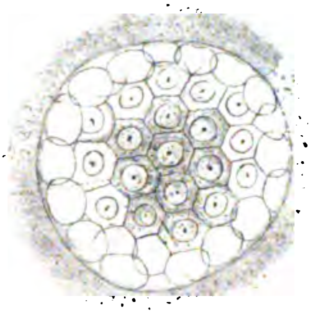

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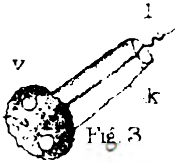

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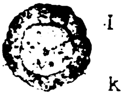

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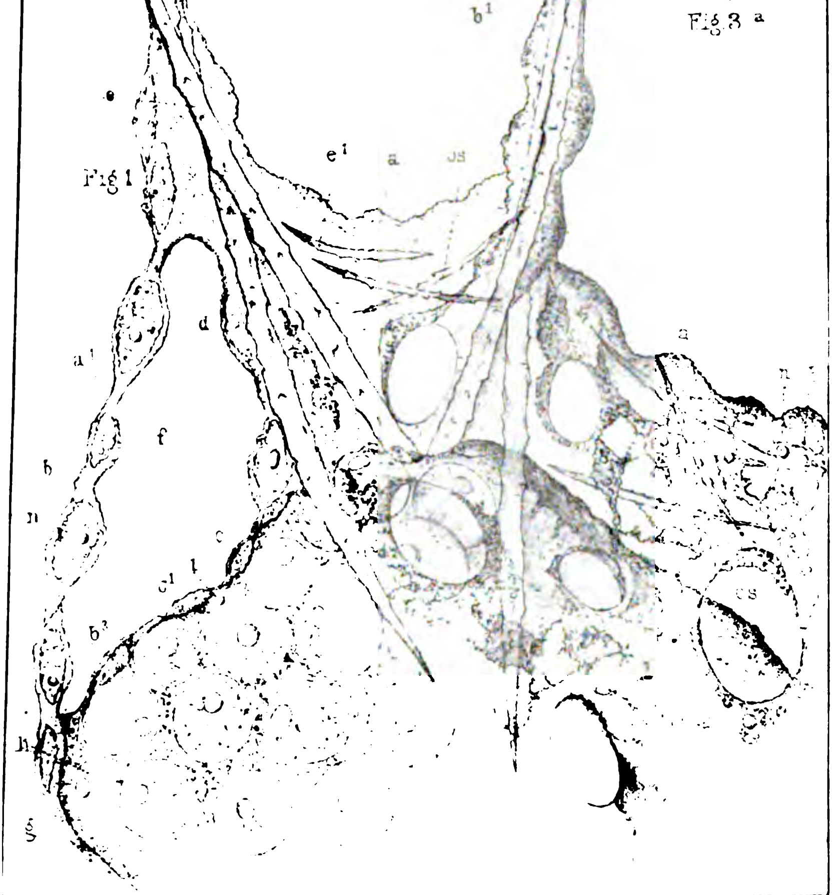

Fig 1

ad nat. H.J.C.

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SPONGILLA ARACHNOIDEA. J-C.